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ASTM BULLETIN

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AMERICAN SOCIETY for TESTING MATERIALS

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DECEMBER—1947

No. 149

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"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

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CABLE ADDRESS—TESTING

Number 149 December 1947

Numerous Actions on Standards

Standards Committee Approves Recommendations Involving Aluminum-Base Alloys, Textile Materials, Adhesives, Petroleum Products, and Others

MANY ACTIONS resulting in numerous new and revised specifications and tests were approved by the Administrative Committee on Standards on October 31 and November 6, based on recommendations from the various technical committees responsible for the products covered. There were numerous recommendations from Committees D-13 on Textile Materials and D-2 on Petroleum Products and Lubricants, and several other technical groups also were involved.

The accompanying table lists the new or revised specifications, and notes on some of the subjects are given below. All of these standards will appear in the 1947 Supplements to the Book of Standards, and a number of the recommendations also will appear in special compilations. This is true in the case of textile materials and petroleum products and lubricants where the respective compilations of standards give the new and revised standards in their latest form.

Aluminum-Base Alloys:

The change in requirements for Aluminum-Base Alloy Sand Castings (B 26) and Permanent Mold Castings (B 108) includes a revision of the iron content for Alloy CS22 from the present 1.2 per cent max. to 1.4 per cent max. Changes in another alloy, SC8, tighten the chemical requirements, and a new 4 per cent copper, 3 per cent silicon alloy in B 26 provides requirements for material that has come into rather widespread use. Revisions in the Ingot Specification (B 179) bring its requirements in line with those for castings.

Textile Materials:

New specifications for mechanical rolled felt cover all standard types

Actions by the A.S.T.M. Administrative Committee on Standards, October 31 and Nov. 6, 1947

New Tentatives

Specifications for:

Mechanical Roll Felt (D 944 – 47 T).

Methods of Test for:

Impact Strength of Adhesives (D 950 – 47 T).
Oxidation Stability of Lubricating Greases by the Oxygen-Bomb Method (D 942 – 47 T).
Oxidation Characteristics of Inhibited Steam-Turbine Oils (D 943 – 47 T).
Penetration of Petrolatum (D 937 – 47 T).
Congealing Point of Pharmaceutical Petrolatums (D 938 – 47 T).
Saponification Number of Petroleum Products by Potentiometric Titration (D 939 – 47 T).
Aromatic Hydrocarbons in Mixtures with Naphthenes and Paraffins by Silica Gel Adsorption (D 936 – 47 T).
Measurement of Density of Hydrocarbon Liquids by the Pycnometer (D 941 – 47 T).
Determination of Purity by Measurement of Freezing Points (D 940 – 47 T).
Water Resistance of Containers by the Spray Method (D 951 – 47 T).
Verification of Calibration Devices for Verifying Testing Machines (E 74 – 47 T).

Tentative Revisions of Standards

Specifications for:

Aluminum-Base Alloy Sand Castings (B 26 – 47 T).
Aluminum-Base Alloy Permanent Mold Castings (B 108 – 47 T).
Aluminum-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 179 – 47 T).
A.S.T.M. Thermometers (E 1 – 47 T).

Methods of:

General Methods of Testing Cotton Fibers (D 414 – 47 T).
Test for Colorfastness of Dyed Cellulose Acetate Rayon to Atmospheric Fumes (D 682 – 47 T).
Knock Characteristics of Aviation Fuels by the Aviation Method (D 614 – 47 T).
Ignition Quality of Diesel Fuels by the Cetane Method (D 613 – 47 T).
Cone Penetration of Lubricating Grease (D 217 – 47 T).
Sulfur in Petroleum Products by the Lamp-Gravimetric Method (D 90 – 47 T).
Sulfated Residue from New Lubricating Oils (D 874 – 47 T).
Sulfated Residue, Lead, Iron, and Copper in New and Used Lubricating Oils (D 810 – 47 T).
Aniline Points and Mixed Aniline Points of Petroleum Products (D 611 – 47 T).
Rust-Preventing Characteristics of Steam-Turbine Oil in the Presence of Water (D 665 – 47 T).

Definitions of Terms:

Relating to Textile Materials (D 123 – 47 T).

Revision of Standard and Reversion to Tentatives

Methods of:

Testing and Tolerances for Cotton Yarns (D 180 – 47 T).
Test for Determination of Small Amounts of Copper, Manganese, and Nickel in Textiles (D 377 – 47 T).
Test for Fineness of Wool (D 419 – 47 T).
Specifications and Methods of Test for Fineness of Wool Tops (D 472 – 47 T).
Test for Burning Quality of Kerosine (D 187 – 47 T).
Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 47 T).
Test for Adhesion of Vulcanized Rubber to Metal (D 429 – 47 T).
Verification of Testing Machines (E 4 – 47 T).

of this material in rolled form. The Specification (D 944) states that:

"felt is a fabric built up by the interlocking of fibers by a suitable combination of mechanical work, chemical action, moisture, and heat without spinning, weaving, or knitting. Felt under these specifications is limited to what is commonly referred to as wool felt and does not include hair, punched, woven, stitched, quilted, paper, or other materials of felt-like appearance which are products of entirely different construction and properties."

There are five standard felt densities in five types. Revisions in the Test for Cotton Yarns (D 180) are intended as improvements in substance and form and revised Methods (D 377) have a number of changes to bring them in line with present practice and the former methods for volumetric determination of copper are incorporated in this revised method.

Committee D-13 has developed a large number of definitions of terms relating to textile materials and when adopted the several new definitions covered in D 123 – 47 T will be embodied in the standard D 123. Some idea of the large number of definitions that have been set up can be had from the fact that the present standard covers some 32 pages, while the new tentative definitions comprise about two and a half pages.

The change in the General Methods of Testing Cotton Fibers (D 414) involves the addition of an alternate method for maturity, using polarized light and a flat bundle method for determining tensile strength. The former standard, D 419, for Fineness of Wool, is now a tentative method, with tentative revisions incorporated and a modification of the short fiber method. Substantially the same action applies to the Methods for Fineness of Wool Tops (D 472). Changes in Tests for Color Fastness of Acetate Rayon (D 682) will bring this method in line with other current procedures. It is based upon developments in the Research Committee of the American Association of Textile Chemists and Colorists. All of these standards pertaining to textiles are given currently in the new compilation of standards sponsored by Committee D-13, and they will also appear in Part III-A of the 1947 Supplement.

Adhesives:

To meet a demand which has existed for some time, Committee D-14 on Adhesives has perfected a new Method for Impact Strength (D 950). It is intended to determine the comparative impact strength in shear. Detailed requirements are given for the metal-to-metal and wood-to-wood specimens, number required, procedure, etc.

Petroleum Products and Lubricants:

In addition to the large number of new and revised tentative methods listed in the accompanying table, Committee D-2 on Petroleum Products and Lubricants has developed eleven tests and related items which it was felt desirable to publish as information only, and this is being done. Nine of these eleven procedures appear in the 1947 compilation of standards in this field. The fourth and the eighth items will be included in the report of Committee D-2 as published in the 1947 *Proceedings*.

PUBLISHED FOR INFORMATION

1. Recommended Practice for the Preparation of New Turbine Lubricating Systems.
2. Method of Test for Evaporation Loss of Lubricating Greases and Oils.
3. Method for Determination of Butadiene Content of Polymerization Grade Butadiene by Koppers-Hinckley Method.
4. Report on Reproducibility and Repeatability of the Method for Determination of Butadiene in Polymerization Grade Butadiene.
5. Method for Determination of Color Index of Petroleum Products by Photoelectric Colorimeter.
6. Method of Test for Sulfur in Petroleum Products by the CO_2-O_2 Lamp Method.
7. Research Procedure for Determination of Mineral Oil Content of Used Lubricating Oil.
8. Report of Subcommittee XI on Methods for Determination of Sulfated Residue.
9. Method of Test for Acid and Base Numbers of Petroleum Oils by Alkali Blue Color Indicator.
10. Method of Test for Acid and Base Numbers of Petroleum Oils by Alpha-Naphtholbenzein Color Indicator.
11. Method of Test for Total Olefinic and Aromatic Hydrocarbons in Gasoline.

In order to give some idea of the subject matter covered by the several new Committee D-2 tests, the scopes of the procedures are given below:

Tentative Method of Test for:

OXIDATION STABILITY OF LUBRICATING GREASES BY THE OXYGEN BOMB METHOD (D 942 – 47 T)

This method describes the test for determining the resistance of lubricating greases to oxidation when stored under static conditions for long periods of time, as, for example, thin coatings on antifriction bearings and on motor parts, etc. It is not intended for the prediction of the stability of greases under dynamic service conditions nor is it intended for the prediction of the stability of greases stored in commercial containers.

OXIDATION CHARACTERISTICS OF INHIBITED STEAM-TURBINE OILS (D 943 – 47 T)

This method of test is intended for the determination of oxidation inhibitor life of inhibited turbine oils, including those used for turbine reduction gears (Note 1).

(NOTE 1.—This method is to be used primarily to determine oxidation inhibitor life and does not necessarily give an indication of the stability characteristics of the base oil following oxidation inhibitor exhaustion.)

PENETRATION OF PETROLATUM (D 937 – 47T)

This method of test is intended for use in measuring with a penetrometer the penetration of petrolatum as an empirical measure of consistency.

CONGEALING POINT OF PHARMACEUTICAL PETROLATUMS (D 938 – 47 T)

This method covers the test for determining the congealing point of pharmaceutical petrolatums or blends of such materials.

(NOTE 1.—This method is an alternate to A.S.T.M. Method D 127, Test for Melting Point of Petrolatum. Results obtained are invariably lower than are obtained by Method D 127, the amount of the deviation varying with the nature of the petrolatum.)

SAPONIFICATION NUMBER OF PETROLEUM PRODUCTS BY POTENTIOMETRIC TITRATION (D 939 – 47 T)

(*a*) This method determines the acidic and basic constituents produced upon saponification of petroleum products under the conditions of the test, as well as those contained in them prior to saponification. The method resolves these constituents into groups having weak-acid, strong-acid, and base ionization properties, provided the dissociation constants of the more strongly acidic compounds are at least 10^3 times that of the next weaker group. It gives erroneous results with materials containing appreciable amounts of strong base. Unsaponifiable compounds whose acid or base dissociation constants in water are smaller than 10^{-9} are not detectable and do not interfere; salts react if their hydrolysis constants are greater than 10^{-9}.

(*b*) The method is applicable to materials that are soluble or nearly soluble in mixtures of benzene and isopropyl alcohol. It is intended particularly for the determination of the saponification number of new and used oils, electrical oils, and greases whether compounded or not. It is useful for the identification of unmixed animal or vegetable oils and for the determination of the amount of fatty material in compounded products, provided the sample does not contain appreciable amounts of certain non-fatty compounds, such as those of sulfur, phosphorus, the halogens, nitrogen, and metals other than potassium or sodium, which consume alkali or acid under the conditions of the test.

AROMATIC HYDROCARBONS IN MIXTURES WITH NAPHTHENES AND PARAFFINS BY SILICA GEL ADSORPTION (D 936 – 47 T)

This method covers the test for the determination of aromatic hydrocarbons in mixtures with naphthenic and paraffinic hydrocarbons. The method is limited to materials boiling in the gasoline range containing not more than about 1 per cent of olefinic hydrocarbons.

MEASUREMENT OF DENSITY OF HYDROCARBON LIQUIDS BY THE PYCNOMETER (D 941 – 47 T)

(*a*) This method is intended for the measurement of the density of any hydrocarbon material that can be handled in a

normal fashion as a liquid at the specified test temperatures of 20 and 25 C. Its application is restricted to liquids having vapor pressures less than 600 mm. of mercury (approximately 0.8 atmosphere) and having viscosities less than 15 centistokes at 20 C.

(*b*) Two procedures are covered as follows: *Procedure A*, for pure compounds and mixtures which are not highly volatile.

Procedure B, for highly volatile mixtures.

DETERMINATION OF PURITY BY MEASUREMENT OF FREEZING POINTS (D 940 – 47 T)

This method is intended for the determination of purity by measurement of freezing points, and is applicable to the substances hereinafter specified, for which are given specifically (*a*) values of the freezing point for zero impurity and the cryoscopic constants to be used for given impurities, and (*b*) the procedures for sampling and measurement.

(NOTE 1.—The method covers systems in which the impurities form with the major component a substantially ideal or sufficiently dilute solution, and also systems which deviate from the ideal laws, provided that, in the latter case, the lowering of the freezing point as a function of the concentration is known for each most probable impurity in the given substance.)

The changes in the various revised methods will be detailed in the 1947 *Proceedings* as part of the Report of Committee D-2, and they, too, appear in their latest form in the 1947 compilation of standards. One item might be mentioned, namely, that the Test for Water and Sediment Using a Centrifuge (D 96) has been reverted to tentative and modification of the pear-shaped tube is being incorporated. This is an improvement over the present tube and gives better accuracy.

Water Resistance of Containers:

The new Test for Water Resistance of Containers by the Spray Method (D 951) is frequently used in conjunction with other tests which are made prior to or after the spray test, such as drop test, impact resistance test, drum test, etc. The method gives requirements on the apparatus, stating, for example, the amount of water which must fall uniformly on each square foot of the area, and details other procedures. Normally, containers are tested as packed.

Adhesion of Rubber to Metal:

The change in the Test for Adhesion of Vulcanized Rubber to Metal (D 429) (now a tentative instead of a standard) involves a revision consisting chiefly of the addition of a stripping method for the evaluation of adhesion of rubber to a single metal plate. This new method has had many applications on war products and is considered a valuable addition to the standard. In addition, a section on adhesion terminology has been added which gives a number of much needed definitions.

Calibrating Testing Machines and Verifying Devices:

Because the requirements for calibrating apparatus used in verifying testing machines are more strict than for the machines and since requirements for both the verifying devices and the testing machines were in the same standard (E 4), it seemed best to separate these requirements; hence, the new tentative for verifying calibration devices (E 74). Requirements on testing machines are continued in the method E 4, but this is now tentative.

Revisions in the Tentative Specifications for Thermometers (E 1) affect two gas calorimeter thermometers, and eventually the requirements on the gas flue thermometer will be withdrawn, but this cannot be done until the Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter (D 900) is revised and that will probably not be until 1948. New specifications for thermometers for oil content of paraffin wax and Stormer viscosimeter thermometer are provided.

1948 Committee Week in Washington

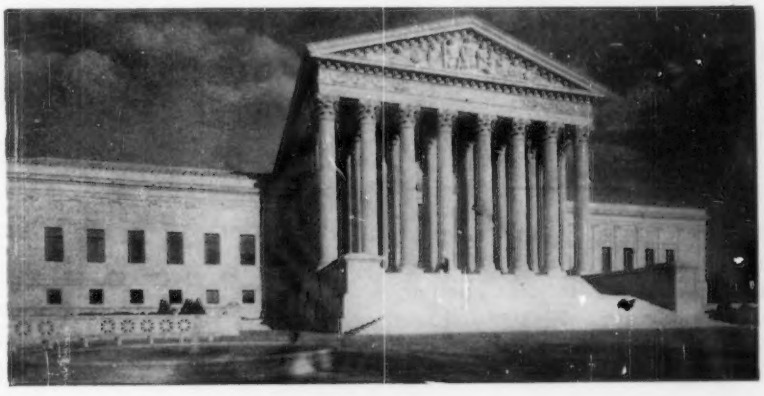
Forty Committees Scheduled to Meet During Week of March 1

TO DATE some forty of the Society's main technical committees have indicated their intention to participate in A.S.T.M. Committee Week which is scheduled for the entire week of March 1, in Washington, D. C. This means that several hundred of the A.S.T.M. members will be in the Capital for various periods during that week.

Detailed information on method of arranging for sleeping room accommodations is being mailed to each member and each committee member early in December. A hotel return form with information on the disposition of committee meetings among the cooperating hotels has been provided.

No Spring Meeting:

Unless there is a change in the plans there will be no Spring Meeting held in 1948 in conjunction with Committee Week—at least so far as a technical session is concerned. For a good many years there has usually been a technical session or two, comprising a symposium or at least related groups of technical papers, during Committee Week. This year the Administrative Committee on Papers and Publications has not developed a technical program but if there are



U. S. Supreme Court

any developments along these lines or if the newly organized Washington District decides on some local affair, a dinner or local meeting, members will be so advised.

Committee Week Information

Present indications are that there will be adequate committee meeting rooms to take care of our requirements at the Hotels Statler, Mayflower, Shoreham, and Wardham Park, with one meeting to be held at the National Bureau of Standards as the preliminary schedule given below shows.

On this schedule no attempt has been made to make a distinction between subcommittee and main committee meetings. It will be assumed, of course, that subcommittee meetings will be scheduled prior to main committee meetings and it is planned to run meetings simultaneously or in sequence as the committees have definitely requested, or as has been their custom in the past.

The Hotel Statler will be the headquarters and the main registration desk will be located there with supplementary registration at the Shoreham. The major part of our meeting room space is at the Statler, but it will be necessary for some of those meeting there to look to other hotels for sleeping room accommodations. In addition to the hotels previously listed, rooms will be made available at the Ambassador, Carlton, Washington, and Willard. It is not planned at this time to hold any meetings at those hotels.

While no advice has been received from some of the committees on whether they will meet, it is known that a number of committees will be meeting independently of Committee Week. A list of these committees includes the following: A-1, C-1, C-14, D-2, D-6, D-7, D-9, D-10, D-12, D-13, D-15, D-20.

Be sure to make your hotel reservations early. Return the hotel form mailed separately, as soon as possible. If you can, plan to share a twin-bedded room with some other member or committee associate.

The Capitol

The chief purpose of A.S.T.M. Committee Week, of course, since its inception some twenty years ago is to enable a member of several different committees to conserve the time spent in traveling to meetings and to enable him in a concentrated period to attend meetings of different committees on which he may hold membership. There are many hundreds of technical men holding membership on several different A.S.T.M. committees, and by arranging a schedule in a concentrated 3 or 4-day period, a considerable amount of expense and time is saved.

It is expected that each committee that is meeting in Washington will furnish its complete membership with a detailed meeting announcement.

Preliminary Schedule for Spring Group Committee Meetings, 1948

Hotel	March 1 Monday	March 2 Tuesday	March 3 Wednesday	March 4 Thursday	March 5 Friday
Statler	A-3	A-5	A-9	B-8	A-6
	A-5	A-7	B-3	D-4	B-8
	A-10	A-10	B-6	D-5	D-8
	B-7	B-7	C-12	D-8	D-14
	C-2	C-17	D-4	D-14	E-5
	D-19	C-18	D-14	E-1	E-7
	E-1	D-18	D-18	E-5	
	E-4	D-19	E-5		
		E-1			
		E-4			
Mayflower	E-9	E-6	D-11	D-11	D-11
			E-6		
Shoreham	D-1	D-1	D-1	B-2	B-5
			B-2	B-5	E-3
			B-5	E-3	
Wardman Park	C-16	C-16	C-16	C-8	
	D-3		C-8	C-15	
National Bureau of Standards		C-11			

PUBLIC BUILDINGS AND WHEN THEY ARE OPEN TO THE PUBLIC[1]

UNLESS otherwise noted all are open daily except Sundays and public holidays. Those marked with a star (*) are open holidays.

Agriculture Department, The Mall between 12th and 14th Sts. Open 9 a.m. to 4:30 p.m.

American Red Cross, 17th and E Sts., N. W. Open 8:30 a.m. to 4:30 p.m.

Archives Building, Constitution Ave., between 7th and 9th Sts., N. W. Open 9 a.m. to 4:30 p.m.

***Arlington Cemetery,** Arlington, Va. Open all day.

Army Medical Museum, 7th and B Sts., N. W. Open 9 a.m. to 4:15 p.m.

Bureau of Fisheries (Commerce Dept.). Open 8 a.m. to 4 p.m.

Botanical Gardens, 1st St. and Pennsylvania Ave. Open 9 a.m. to 4 p.m.

Commerce Department, Constitution Ave., 14th and 15th Sts., N. W.

Capitol, Capitol Hill. Open 9 a.m. to 4:30 p.m.

Corcoran Gallery, 17th St. and New York Ave. Open 9:30 a.m. to 4 p.m. (Closed July 4 and Christmas Day.) Free admission on Tuesdays, Thursdays, Saturdays, Sundays, and public holidays; 25 cents admission on Mondays, Wednesdays, and Fridays. Time of admission: Sunday, 2 to 5 p.m.; Monday, 12 Noon to 4:30 p.m.; other week days, 9 a.m. to 4:30 p.m.; public holidays, 2 to 5 p.m.

Freer Art Gallery, 12th St. and Independence Ave., S. W. Open 9 a.m. to 4:30 p.m. (Every day except Monday.)

Internal Revenue, Constitution Ave., between 10th and 12th Sts., N. W.

Interstate Commerce Commission, Constitution Ave., at 12th St. N. W.

Labor Building, Constitution at 14th St. N. W.

***Library of Congress,** Capitol Hill. Open 9 a.m. to 10 p.m.

Lincoln Memorial, Potomac Park. Open 9 a.m. to 9:30 p.m.

Lincoln Museum, 516 10th St. N. W. Open 9 a.m. to 4:30 p.m.

Memorial Continental Hall, 17th and D Sts. N. W. Open 9:30 a.m. to 4 p.m.

Mount Vernon, 16 miles south of Washington. Open daily, 9 a.m. to 4 p.m.; Sundays, 2 p.m. to 4 p.m.

National Academy of Sciences, 22nd and B Sts. Open 9 a.m. to 5 p.m.

National Gallery of Art, Constitution Ave. at 6th St. N. W.

***National Museum,** Smithsonian Grounds. Open 9 a.m. to 4:30 p.m. (New building open, also. Sunday, 1:30 to 4:30 p.m.)

Pan American Union, 17th and B Sts. Open 9 a.m. to 4:30 p.m.

Pension Bureau, New Commerce Building. Open 8 a.m. to 3:30 p.m.

Post Office Department, 12th St. and Pennsylvania Ave. Open 9 a.m. to 4:30 p.m.

Public Health, Constitution Ave., between 19th and 20th Sts. N. W.

***Smithsonian Institution,** Smithsonian Grounds. Open 9 a.m. to 4:30 p.m.

***Soldiers' Home,** 7th St. extended. Open 9 a.m. to sunset.

Supreme Court, Maryland Ave. at 1st St. N. E. Open 9 a.m. to 4:30 p.m.

Washington Cathedral, Mt. St. Albans. Open all day.

Washington Chapel, 2810 16th St. N. W., cor. Columbia Rd. Open for free organ recitals and inspection. Mondays, Wednesdays, and Fridays at 8 p.m.; all day Sundays.

***Washington Monument,** Washington Park, near 14th St. Open 9 a.m. to 4 p.m. Summer to 10:30 p.m.

***Zoological Park,** Rock Creek, Adams Mill Road. Open all day.

[1] From the *Hotel Greeters' Guide.* Copies available at 25 cents from Hotel Greeters of America, Washington Chapter 31, Southern Building, Washington, D. C. Those planning to visit Washington for the first time would find this Greeters' Guide of much interest and assistance.

About Washington[1]

BROAD as was the vision of George Washington and Pierre L'Enfant when in January, 1791, they viewed the flat lands which were selected as the site for the U. S. capital, it is doubtful if they had any conception of what a majestic city would one day rise in that area. It took the Continental Congress considerable time and much discussion to weigh the various offers and conflicting opinions, and select the banks of the Potomac near old Georgetown for the capital.

Ten square miles were ceded by the states of Maryland and Virginia but later the section yielded by Virginia including the town of Alexandria was ceded back.

Under provisions of the Residence Bill of 1790, Congress removed the seat of government to Washington, or the Federal City, on the first Monday in December, 1800. The transfer was accomplished without much difficulty as the government personnel at that time is said to have consisted only of 126 persons.

The White House, or "President's Palace," as it was then called, was the first government building completed in Washington.

In 1801 a temporary building, popularly called "The Oven," was constructed on part of the foundation of the South Wing of the Capitol. Here the sessions of the House of Representatives were held until 1804.

For many years Washington was no more than a village with hovels and muddy streets provoking the nickname of "City of Magnificent Mudholes." Its growth was not accelerated to any appreciable extent until the Civil War. Since then progress of the city has been steady and orderly until today it ranks among the truly great cities of the world.

L'ENFANT'S PLAN

The National Capital, with its 682 parks, its broad tree-lined avenues, and magnificent vistas, in general represents the vision of Maj. Charles Pierre L'Enfant, a young French engineer employed by Washington in the designing of the Federal City.

It it not possible here to go into detail regarding L'Enfant's Plan, which was without precedent in city designing. L'Enfant's dream of a capital both novel and magnificent stressed circles with radiating avenues and right angle streets, broad and tree-lined. His idea was to have the mile stretch between the Capitol and the White House a scene of grandeur and beauty, with mansions of foreign ministers, gardens, sloping lawns, and a great religious temple. These did not materialize, but in their place today is the greatest array of government buildings in the world—the $300,000,000 worth of government buildings in the Federal Triangle.

The Mall, now one of the show places of the city, originated with L'Enfant. This development extends from the Capitol to the Lincoln Memorial, taking in the landscaped areas of the Department of Agriculture and the 70 acres of the Sylvan Theater surrounding the Washington Monument and the Smithsonian Grounds. If L'Enfant could see the Mall, with its $2,000,000 Lincoln Memorial and great reflecting pool, he would realize that his work had not been in vain.

[1] Based on information from the Washington Board of Trade.

Washington's Mansion Mt. Vernon, Va.

Several Symposiums, Apparatus Exhibit, to Feature 1948 Annual Meeting

Technical Sessions, Committee Meetings and Exhibit Throughout the Week of June 21, 1948, in Detroit

THE week of June 21 will be a very intensive one for the thousands of members and committee members expected to be present at the Society's 51st Annual Meeting in Detroit. Throughout the week there will be numerous technical sessions, including those at which will be held some seven formal symposiums, and several hundred technical committee meetings will be in progress. Also being held through the five days of the 1948 meeting will be the Eighth A.S.T.M. Exhibit of Testing Apparatus and Related Equipment, featuring displays of new research and testing instruments, and laboratory supplies, in booths sponsored by leading manufacturers and distributors.

While the center of meeting activity will be the Book-Cadillac, the official Headquarters Hotel, it may be desirable to set up auxiliary registration at some of the other cooperating hotels. It is necessary, in order to provide sufficient number of sleeping rooms, to use facilities of the Statler, Detroit Leland, Fort Shelby, Tullar, and others. Of particular significance is the fact that meetings of technical committees, and perhaps a few of the technical sessions also, may be scheduled in some of these hotels, especially the Statler, which is just a few minutes' walk from the Book-Cadillac.

The Exhibit of Testing Apparatus and Related Equipment, and the Photographic Exhibit and competition will be in the Book-Cadillac adjacent to the A.S.T.M. registration desk.

Detroit Committee:

The Detroit Committee on Arrangements, with C. H. Fellows, Detroit Edison Co., as chairman, is completing its personnel, and has held meetings of the men who will head the specific activities. V. M. Darsey, Chairman of the Detroit District Council, who appointed the Committee on Arrangements is serving as local committee Vice-Chairman, with Harvey Wagner, Detroit Edison Co. as Secretary. C. E. Heussner, Chrysler Corp., Detroit Council Secretary, is head of the important subcommittee on Annual Dinner and Ladies' Entertainment. J. L. McCloud, Ford Motor Co., is responsible for the Apparatus and Photographic Exhibits, and F. C. Gambrill, Ethyl Corp., is working on hotels and housing accommodations. Publicity and promotion will be in the charge of a committee headed by F. C. Kennedy, U. S. Rubber Co., and F. P. Zimmerli, Barnes-Gibson-Raymond Div., Associated Spring Corp., is heading the group concerned with plant visits and local transportation. B. C. Case, Hanson - VanWinkle - Munning Co., will be responsible for the Committee on Finance.

Ladies Invited:

While details will be furnished members and committee members later on some of the entertainment plans, it can be announced that on Wednesday, June 23, there will be a dinner and dance. A most interesting program of events for the ladies' entertainment is being developed, and members are urged to plan to bring their families with them, because the ladies will have plenty to do and see throughout the week of the meeting.

The Housing Committee, working closely with the Detroit Convention Bureau, has assurance of ample accommodations for any members and committee members and visitors who may be present. Not all members can be accommodated at the hotel of first choice, but the committee feels that comfortable facilities will be available.

Exhibits

The Exhibit of Testing Apparatus and Equipment has come to be looked on as a desirable and important adjunct of annual meetings held in industrial centers. Satisfactory instruments, laboratory supplies, and related materials are such an important part of many phases of testing and research that there is hardly a technical committee of the Society that is not vitally interested in some phases of instrumentation, and of course a large number of A.S.T.M. specifications and tests embody references to a wide range of testing equipment.

Manufacturers and distributors of instruments and laboratory equipment are being invited to sponsor commercial displays in the exhibit and many of them will participate. The meeting does offer a splendid opportunity for them to contact large numbers of men who are vitally concerned with this field.

The exhibit will be held in the Book-Cadillac's ballroom and Italian Garden, both of which are adjacent to the official A.S.T.M. Headquarters Registration Desk.

Photographic Exhibit:

A local committee on photographic exhibit is being appointed under the direction of J. L. McCloud, General Exhibits Committee Chairman, and this group will sponsor the Eighth Photographic Exhibit which will be set up in the Book-Cadillac's ballroom. Each member and committee member of the Society will receive an entry form giving the rules for participation in the exhibit. There will be details on the two specific sections dealing with photomicrography and radiography, as well as the general section. Further details will be furnished later, but members who are interested should note this affair and plan to participate.

Committee Meetings

Even though advice on "which" committees will meet at "what" hotels must be taken care of later, members can definitely count on having certain groups of committee meetings held in some of the cooperating hotels, other than the Book-Cadillac. Neither the Book

nor any other hotel has sufficient meeting room space to accommodate the present type of A.S.T.M. meeting. Sometimes as many as 40 committee rooms are required to hold simultaneous meetings.

The plan with respect to the Detroit meeting is to advise each member the hotel at which a respective committee will meet, and the member can then decide whether he would like to apply for sleeping room accommodations at this hotel or elsewhere. Much this same plan is to be in effect for A.S.T.M. Committee Week in Washington during the week of March 1—see article elsewhere in this BULLETIN.

Technical Features

AT LEAST six formal symposiums are scheduled for the 1948 Annual Meeting and there will be numerous other sessions devoted to specific topics. Brief notes on some of these symposiums and special sessions are given below and, of course, there will be further details. It is planned that the Provisional Program for the meeting which gives a rather complete advance picture of the technical features will be published in the May BULLETIN, or distributed separately as far in advance of the meeting as possible.

Perhaps the one general observation to be noted at this stage is that a very strong technical program is assured for the meeting.

SYMPOSIUM ON MINERAL AGGREGATES

This symposium being developed under the auspices of Committee C-9 on Concrete and Concrete Aggregates will be a very extensive one. A number of the country's leading authorities will participate. At this time it is possible to announce the general scope of the symposium and to list some of the topics that will be definitely covered. Probably at least two complete sessions will be devoted to this technical feature. It will unquestionably be of very widespread interest.

Proposed Scope:

The enormous demand since the war for mineral aggregates as materials of construction, has focused attention on the need for complete and up-to-date general knowledge of the characteristics and uses of these materials. In this way more intelligent and economical use can be made of them. The original symposium on mineral aggregates, held in 1929, filled such a need at that time. However, a new symposium on this subject in which the purpose of each paper will be to give the present-day picture of each particular phase that it covers is now in order, especially to point out the development that has taken place since the presentation of the original symposium almost twenty years ago.

The coverage of the particular subject assigned to each contributor, whether the subject is restricted or comprehensive, is broad and not confined to the local area or local connections with which he might be most familiar. Finally, the papers in this symposium are written primarily for that group of individuals interested in the characteristics and uses of mineral aggregates but who normally are not intimately connected with the aspects of research and testing.

SYMPOSIUM ON MINERAL AGGREGATES

GEOLOGIC ORIGIN AND DISTRIBUTION OF MINERAL AGGREGATES
MINERALOGICAL CHARACTERISTICS—PHYSICAL AND CHEMICAL—OF AGGREGATES
PHYSICAL AND CHEMICAL TESTS AND THE SIGNIFICANCE OF THESE TESTS
SAMPLING OF MINERAL AGGREGATES
PRODUCTION AND MANUFACTURE OF FINE AND COARSE AGGREGATE
GRADING OF AGGREGATES
  Section 1—Bituminous
  Section 2—Concrete
INFLUENCE OF MINERAL AGGREGATES ON THE STRENGTH AND DURABILITY OF CONCRETE
LIGHTWEIGHT AGGREGATES
MINERAL AGGREGATES IN BITUMINOUS MIXTURES
LOW-COST ROADS AND BASE COURSES—WATER-BOUND MACADAM
MINERAL AGGREGATES FOR RAILROAD BALLAST
OTHER USES
  a. Mineral Aggregates for Sewage Disposal Usage
  b. Mineral Aggregates in the Chemical Processing Industry
  c. Mineral Aggregates for Special Uses—Riprap; Mineral Wool
  d. Fine Aggregate in Mortar and Plaster
NEEDED RESEARCH

SESSION ON EFFECT OF TEMPERATURE

The Joint Committee on Effect of Temperature which functions under the auspices of the A.S.M.E. and A.S.T.M. will sponsor a Session on Effect of Temperature. The exact number of papers and the specific phases of this subject that will be stressed remains to be developed by the Joint Committee, but it is probable that some of the papers will be concentrated on turbine disk problems.

SYMPOSIUM ON MAGNETIC TESTING

With the exception of the members of A.S.T.M. Committee A-6 on Magnetic Properties and a relatively small, but nevertheless rapidly growing group, of individuals and organizations using magnetic testing, others may feel that this subject is a relatively restricted one. However, a review of the topics to be covered in the 1948 symposium at the Detroit meeting, which Committee A-6 is sponsoring, will indicate that there are many aspects to this field, and an immediate secondary reaction is that it undoubtedly has a rather wide-spread application. Of course, the positive third reaction would be that attendance at the symposium will be one of the finest ways to get a real conception of not only the basic problems but the new developments in this field. A tentative program for the meeting follows—as usual at this stage it is subject to change and final details will not be made available until later.

SYMPOSIUM ON MAGNETIC TESTING

BASIC PRINCIPLES AND EQUIPMENT FOR PRACTICAL MAGNETIC ANALYSIS—P. E. Cavanagh
ACCEPTANCE AND PRODUCTION TESTS OF PERMANENT MAGNETS—C. A. Maynard
METALS COMPARATORS—B. M. Smith
THE TESTING OF MAGNETIC RECORDING MEDIA—H. A. Leedy
HYSTERESIS LOSS—R. R. Field
MAGNETIC ANALYSIS OF POINT INSPECTION METHODS—T. Zuschlag
STUDY OF 25-CM. EPSTEIN TEST METHODS—J. A. Ashworth
D-C PERMEABILITY TESTING USING THE 25-CM. EPSTEIN FRAME—D. C. Dieterly

SYMPOSIUM ON X-RAY AND GAMMA RAY

Under the chairmanship of L. W. Ball, Naval Research Laboratories, the Papers Committee of Committee E-7 on Radiographic Testing will develop a symposium for the Annual Meeting dealing with the inspection and testing of assemblies, that is, products as distinct from single materials. This will undoubtedly involve a discussion of the use of ultra-high voltage machines and equipment, and by the time of the meeting some very interesting results should be available. At the same time the committee may include some further information on using high-voltage techniques.

In addition to this potential symposium, the committee is considering a separate session involving nondestructive testing methods, but whether this will take the form of a round-table discussion, individual papers, or a formal symposium, has not yet been decided.

SYMPOSIUM ON GREASE

The purpose of this symposium, being sponsored by Technical Committee G on Lubricating Greases, which functions as part of Committee D-2, is to discuss tests of ball bearing greases and the correlation

of the results of these tests with service performances. It has been suggested that this subject might be covered in several papers which would deal with service, simulated-service, accelerated-service, and laboratory testing. There has been steadily growing interest in this field, various testing machines have been devised, and it is expected some of the papers at least will include data on rather extensive use of the equipment.

Symposium on Usefulness and Limitations of Samples

In arranging for this symposium Committee E-11 on Quality Control of Materials has in mind that possibly three papers would be prepared, followed by written and oral discussion. Almost everyone concerned with evaluation of materials is interested in sampling processes, with respect to the number of samples taken and just how well these represent the material or products being tested, etc. Committee E-11 believes that this symposium should focus attention on the practical aspects of the subject, and that the papers would be so prepared as to interest the nonspecialist in this field of quality control and statistical analysis.

Symposium on Metallography in Color

Partly in recognition of the growing use of metallographic work in color, but also to stimulate interest in the latest techniques and thoughts on procedure, equipment used, and results, Committee E-4 on Metallography is arranging this symposium for the Annual Meeting. In conjunction with the symposium, Committee E-4 is sponsoring a section on photo-micrography including the use of color, in the 1948 Photographic Exhibit during the Annual Meeting.

Some of the subjects to be covered in papers include the following: Application of Color Metallography; Application of Color Photography to the Study of Nonmetallic Inclusions; Color Metallography Simplified; Color Film in Metallographic Work; Determination of Exposure.

Corrosion of Pressure Vessels

Committee D-19 on Water for Industrial Uses in cooperation with the Joint Research Committee on Boiler Feedwater Studies is preparing a Panel Discussion on The Influence of Non-Ferrous Metals and Their Compounds. For the last three years, this committee has sponsored programs in which the major emphasis has been on the role of mineral deposits and means for the identification of such products by special methods. This year the Committee believes it would be of timely interest to power plant operators and equipment manufacturers to consider the effect on corrosion of the deposition as sludges, or as metals, of non-ferrous metals and their compounds in pressure vessels. It is realized that data on the subject are scarce but it is hoped by having preprints prepared well in advance of the meeting to develop the "hidden data" that might be in the files of power companies, operators, etc.

A series of three papers are in preparation: (1) describing typical modern steam electric power plants, showing essential equipment and metals used in their construction; (2) factors involved in pressure vessel corrosion; and (3) discussion of present available data. The authors are, in order: R. B. Donworth, Betterment Engineer, Duquesne Light Co.; V. V. Kendall, Corrosion Engineer, National Tube Co.; and R. C. Corey, Supervising Engineer, Combustion Research Section, U. S. Bureau of Mines. These papers will present the picture and the discussion to follow should be of vital interest to the power industry.

General

In addition to the formal symposiums, there will be a number of sessions devoted to specific topics, such as: Industrial Waters, Concrete and Concrete Aggregates, Soils for Engineering Purposes, Testing Methods, etc.

About Detroit[1]

Founded by Antoine de la Mothe Cadillac in 1701, Detroit has known many colorful episodes in its rapid growth to the status of America's fourth largest city and a leader in industrial progress.

Because of its strategic location on the strait (the Detroit River) that connects two great lakes (St. Clair and Erie), many fierce battles were fought for its possession as a most vital link on the wild new world's frontier. Flags of three nations have flown over the city.

As Detroit grew it rapidly became famous for the manufacture of stoves, pharmaceutics, and other commodities.

Suddenly, one hot day in 1894, Charles King drove his fire-emitting, horseless carriage down the streets of the city at the breathless speed of 15 mi. per hr. Pandemonium reigned and the flabbergasted city council promptly passed an ordinance limiting the new-fangled buggy to a speed of 3 mi. per hr.

Today, Detroit has few peers throughout the world as an industrial city. Not only has the automobile catapulted the city to heights of mechanical production, but Michigan's resources have supplied the incentive for many other industries to make Detroit their permanent home.

The quiet river which at one time was valued chiefly for its strategic military value is today one of the busiest inland waterways in the world.

A Few Facts:

Detroit owns its own street railway system and bus lines carrying over half a billion passengers annually.

Approximately 780 churches represent all denominations.

Three great metropolitan dailies, *News*, *Times*, and *Free Press*, have a combined daily circulation of more than 1,000,000.

Nine railway systems operate from three Detroit terminals.

The population of Detroit, America's fourth largest city, is approximately 1,625,000.

Detroit has more than 2451 manufacturing establishments and the average annual income of workers is highest in the nation.

Educational facilities in Detroit include 255 public schools, 8 colleges, Wayne University, University of Detroit, Marygrove, Cranbrook, 19 high schools, and 110 parochial schools.

Belle Isle

[1] Based on information from the Detroit Convention and Tourist Bureau.

Notes on Publications

WORK by the authors, editors, and printers of the books and pamphlets scheduled for publication is proceeding apace. The October BULLETIN gave notes on a number of symposiums and special compilations of standards which were in the making, and several of those have become available and have been distributed. Five compilations have been completed fairly recently including those covering Copper and Copper Alloys, Petroleum Products and Lubricants, Coal and Coke, Electrical Insulating Materials, and Textile Materials. Of these the one on Petroleum Products and Lubricants is the largest, aggregating about 710 pages, and is most widely distributed. In connection with this particular publication there is an accompanying article dealing with another book, really a companion volume, entitled "Manual of Engine Test Methods for Rating Fuels."

With respect to technical symposiums and related items, Symposiums on Synthetic Lubricants and on Rubber Testing have come off press, and the 1947 Edgar Marburg Lecture by Professor Voss on Engineering Laminates is also available as a separate reprint from the *Proceedings*.

Work continues on the 1947 Supplements to the Book of Standards, with Part I-B on Non-Ferrous Metals completed, Part II on Nonmetallic Materials—Constructional in the bindery, and work on the other three Parts in various stages of completion. The schedule indicates that special compilations of standards in the field of Cement, Plastics, Rubber and Rubber Products, Steel Piping Materials, and Refractories will be available early in 1948. The press work on the Supplements to the Book of Standards governs the times when these compilations can be issued, since the type used to print the Supplements is also used in the compilations.

1947 Standards on Soaps and Other Detergents

THIS 185-page volume just available in a revised edition has some 24 specifications and 7 test methods which have been developed through the intensive work of Committee D-12 on Soaps and Other Detergents. The specifications cover bar, chip, powdered, salt water, toilet and other kinds of soaps, and numerous detergents including soda ash, bi-sodium phosphate, and others. The methods relate to the sampling and chemical analysis of soaps and detergents, and tests for particle size and a series of definitions. The book is made more complete by an extensive bibliography of metal cleaning which includes a wealth of annotated material. Copies of this book can be procured by members at $1.50 each, list price being $2, in heavy paper cover.

Members' Order Blank Lists New Publications

Numerous Publications Described Briefly, with Special Price to Members Noted

EARLY in December there is being mailed to each member of the Society a special order blank by which members can order copies of many of the new publications and also procure copies of books and pamphlets which have been issued in previous years. This special order blank will be accompanied by a new List of Publications and other material. Formerly it was the practice to send an order blank of this kind just once during the year, but the heavy publication schedule and the uncertainty of appearance date of some of the books have led to a decision whereby there will be a members' order blank late in the year and another one about April. The latter will cover books that became available or were scheduled after the December order blank was issued.

One of the advantages of membership in the Society is the privilege of procuring practically all publications at considerably reduced prices, and it is apparent from the heavy volume of orders received throughout the year that members appreciate this privilege.

Obviously if the Society's work, both in standardization and in research, is to be of maximum benefit, the more widely disseminated are the publications the more significant will be the results of the standardization and research activities.

Year Book Completed

THE 1947 A.S.T.M. Year Book has been completed and copies are being mailed to those members who have requested it. This book is sent only on request. Those who wish a copy and who have not returned the request card sent earlier should do so at their earliest convenience.

The 1947 Year Book does not differ in any major respect from those issued earlier, but it continues to grow in size. Some additional information is included, however, for the first time, in the section devoted to geographical distribution of members. Here appropriate key numbers are given states or localities, which are a part of the A.S.T.M. Districts that have been organized. It happens that sometimes a whole state falls in the district in which case the key number applies to the entire state, or, as in most instances, the community is given a key number. Most of the districts have had their areas considerably expanded and the Year Book classifications take into account these increased areas.

Following general information about the Society in the forepart of the book, including details on membership and rather complete data on Annual and Spring Meetings there is a list of District Counselors. Then follow lists of Honorary Members and the Sustaining Members and in turn the general list which comprises a large portion of the book. Here

each member as of October, 1947, is listed and there is a cross reference with the name of the official membership representative of each company or association. Dates of membership are given and complete addresses and titles. Immediately following the main membership list there is a list of the Forty-Year members, and then the geographic distribution.

Committee Personnel:

The section of the Year Book devoted to committee personnel occupies more space than any other subject. Here are listed the titles and scopes of the some 70 major A.S.T.M. technical committees, research committees, and sectional committees, together with the current officers and their addresses; a list of the Past-Chairmen and Secretaries follows and finally the complete personnel of the respective committees classified as Producer, Consumer, and General Interest.

Any member, or nonmember, reviewing this committee personnel section of the Year Book could not help but be impressed with the variety and extent of the committees. There are several hundred subcommittees and sections detailed in addition to the main groups. With the personnel of main committees ranging in number from 35 to 400, it is not surprising that almost 250 pages are needed to give the complete listings.

The current yearbook comprises some 540 pages in heavy paper cover.

Where to Look for Information—or Data May Be in Strange Places

THE PROBLEM of classifying a technical paper according to the materials field in which it is of major interest is a difficult one at times. For example, if the paper on "Introduction to Statistics" by A. E. R. Westman, published in the October BULLETIN and also a part of the forthcoming Symposium on Paint and Paint Materials were indexed under the topics or materials where it would be of major interest, we would have to list every materials field in which A.S.T.M. is active because this paper is one of those broad interest papers that will repay reading by every member of the Society. Other contributions not of such broad interest, nevertheless carry very helpful data and information to readers who may not be concerned with the particular field involved. Two such papers appear in this BULLETIN. Presented at a meeting sponsored by Committee D-13 on Textile Materials, they deal with strain gages and stress-strain testers as used in the textile industry. These short papers are worth perusing by anyone concerned with testing, for the applications covered may have much wider significance than textiles.

Still another example is the paper by E. N. Harvey, Jr., to be a part of the paint symposium dealing with particle size by gas adsorption. This is one of the few papers published by A.S.T.M. dealing with this method of determining particle size. While the work involved studies of carbon blacks, white pigments and extenders, inorganic colors and organic pigments, it is probable that this method of attack may come into much wider use than solely in the field of pigments. Of incidental interest is the splendid bibliography of 72 references, a part of this paper. How to acquaint everyone concerned with particle-size measurement with this paper is a problem that we can solve only partly. Presumably the alert technologists find many of these items somehow and use what they can in their fields. The whole subject indicates that our members need to be alert to the significance of the technical papers that are published by the Society.

A.S.T.M. Manual of Engine Test Methods for Rating Fuels

This Manual, issued for the first time by A.S.T.M., presents in their latest approved form the five standard methods for rating motor, aviation, and Diesel engine fuels. There is a wealth of supplementary information concerning not only operation and maintenance details, but also building and utility requirements, installation and assembly of the engine, and reference fuels.

$8.00 per copy; to A.S.T.M. members, $6.00. Cloth binding.

Further information in January BULLETIN.

Discussion on Speed of Testing Available

THE Round-Table Discussion on Speed of Testing held during the 1947 Annual Meeting has been edited and has been duplicated. Those interested can obtain copies at 50 cents a set. This material covers 24 pages on letter-size sheets. The round table was a preliminary step to a formal symposium to be held at a subsequent Annual Meeting.

A.S.T.M. Establishes Ordnance Advisory Committee

UPON invitation of the Ordnance Department, U.S.A., extended on behalf of the Chief of Ordnance by General H. B. Sayler, Chief, Research and Development Service, O.D., the Board of Directors of the Society has authorized the establishment of an A.S.T.M. Ordnance Advisory Committee. President Boyd has appointed the following members, all of whom have accepted:

C. L. Warwick, Executive Secretary, A.S.T.M., *Chairman*
A. W. Carpenter, Manager of Testing Laboratories, The B. F. Goodrich Co.
P. V. Faragher, Metallurgist, Aluminum Company of America.
W. H. Finkeldey, Member of Firm, Singmaster & Breyer
Neil A. Fowler, Vice-President and Director of Research, General Box Co.
J. C. Geniesse, Research Chemist, The Atlantic Refining Co.
J. J. Kanter, Materials Research Engineer, Crane Co.
N. L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp.
H. K. Nason, Director of Development, Central Research Dept., Monsanto Chemical Co.
J. R. Townsend, Materials Engineer, Bell Telephone Laboratories.

Carter S. Cole, Assistant Technical Secretary of the Society, will serve as Secretary of the Committee.

The committee's contacts with the Ordnance Department will be made through Lt.-Col. G. F. Powell, who heads the Research and Materials Branch in the Research and Development Division of the Ordnance Department, and Mr. Hollady.

The purpose of the committee is, briefly, to advise the Ordnance Department, upon request, on problems relating to tests and specifications for ordnance materials—more especially problems other than those relating directly to the work of the Society's technical committees, which are being referred from time to time directly to those committees by the representatives of the Ordnance Department on the respective committees. There are a variety of problems involving special considerations, such as specific researches by the Ordnance Department, concerning which advice from a committee constituted especially for that purpose can be obtained more quickly and more effectively than through the established technical committee procedures. Further, it is expected that advices will be sought on problems that have no immediate current commercial significance and may not therefore be on the agenda of any of the Society's committees.

The first meeting of the Ordnance Advisory Committee was held in Washington on October 15. After formal organization was effected, the committee met in conference with General Sayler and a number of members of the staff of the Research and Materials Branch. Present at this conference were the following:

Representing the Ordnance Department: General Sayler, Lt.-Col. R. B. Baker Jr. (representing Colonel Powell), and Messrs. E. L. Hollady, C. R. Cornthwaite, G. Reinsmith, R. W. White, G. G. Allan (representing N. L. Klein), and L. C. Heller.

Representing A.S.T.M.: Messrs. Carpenter, Faragher, Fowler, Geniesse, Kanter, Warwick, and Cole.

Various members of the Ordnance Department staff reviewed a number of the Ordnance research and development programs, which included the types of problems which will be submitted to the committee from time to time for consideration. The materials fields covered by this presentation included ferrous and non-ferrous metals, protective coatings and finishes, fuels and lubricants, hydraulic fluids and rust preventive compounds, packaging materials and methods, adhesives, rubber, plastics, and some current specification problems of broad applicability.

It developed that certain research projects of the Ordnance Department were about to reach the stage where advice from A.S.T.M. could be most helpful, and the committee was asked to set up small Advisory Research Panels on these projects covering, respectively, rubber, adhesives, and plastics. The organization of these panels is nearly completed, and the panels will shortly be available to respond to the call of the Ordnance Department for consultation.

The committee is "standing by" prepared to respond to requests from the Ordnance Department for advice and consultation on any problems within the Society's field. It is planned to hold a second conference with the Ordnance staff next spring.

Forum on Tractor Fuels

ALL members of the Society and others interested are invited to attend a Forum on Tractor Fuels which is being sponsored by Technical Committee I on Tractor Fuels, functioning under A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. This is to be held on January 9, 1948, in the Michigan Room of the Edgewater Beach Hotel, Chicago, Ill., at 1:30 in the afternoon.

Mr. Earl M. Hughes, Chairman of Technical Committee I, will preside over the program which is as follows:

Tractor Statistics as Related to the Farmer—H. E. Everett, Editor and Vice-President, *Implement & Tractor*
The Farmers' Interest in Tractor Fuels—E. L. Barger, Professor, Agricultural Engineering Dept., Iowa State College
A Review of Tractor Requirements as Related to Fuels—Raymond Bowers, Assistant Chief Engineer, Mechanical Research and Development Div., International Harvester Co.
The Complexity of Tractor Fuels and Taxation—A. B. Anderson, Director of Petroleum Div., Department of Taxation, State of Minnesota
The Effect of State Tax Regulations and State Specifications on Tractor Fuels from the Petroleum Industry Standpoint—C. N. Hinkle, Tractor Representative, Sales Technical Service Dept., Standard Oil Co. (Indiana).

There will be discussion of each paper following presentation.

ASTM Bulletin

DECEMBER 1947

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NINETEEN-SIXTEEN
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PHILADELPHIA 3, PENNA.

Building Fund Progresses

As a result of contacts which the officers of various technical committees have been making with their membership in the program of eliciting the aid of committee members in expanding the A.S.T.M. Building Fund, the total now earmarked from committee contacts has reached the total of about $4500. While this figure includes some rather substantial contributions from various companies, nevertheless, one of the very desirable aspects of the fund raised by committees is the large number of committee members who are participating.

Early in the summer the Board of Directors contacted the officers of each technical committee suggesting that they might wish to take some action in interesting their members in the Fund. This move was brought about in part by the activities of two or three of the technical committees which had earlier evidenced an interest and started a project in their respective groups.

The October Bulletin carried a list of some 20 committees which have taken steps to bring this fund to the attention of their members. It is known that a number of the other committees plan to participate in the fund but are deferring any action until 1948.

The total amount contributed by the Society's members and friends, a large part of which was subscribed by leading companies, has reached about $162,000. With the building costs aggregating about $185,000, the ultimate goal is set at about another $20,000.

The following organizations and individuals have recently contributed substantial sums, either earmarked for technical committee credits or directly to A.S.T.M. as a result of earlier invitations.

American Creosoting Co.
American Die Casting Inst.
Associated Factory Mutual Fire Insurance Cos.
Robert D. Bonney
W. H. & L. D. Betz Co.
Cementos Atoyac S. A.
Harbison Walker Refractories
Edward Jacobi
Ledoux & Co., Inc.
North American Smelting Co.
Pabst Brewing Co.
H. H. Robertson Co.
Southern Cement Co.
United Carbon Co.
United States Rubber Co.

Amendment on Dues Approved

Each member of the Society is being advised by letter that the amendment of the By-laws relating to increased membership dues which by action at the Annual Meeting was referred to letter ballot, has been approved overwhelmingly, with 849 affirmative votes cast and 56 negative. Of the total ballots received, 952, there were 47 marked not voting.

Since the number of affirmative votes exceeds two-thirds of those voting, as required by Article X of the By-laws for adoption, the Board of Directors has declared the amendment adopted, to become effective with the next fiscal year. Accordingly, membership dues for 1948, to be billed on January 2, will be as follows:

Class of Membership	Annual Dues
Sustaining	$150
Company	50
Individual	18
Junior	9
Student	2

"Accent on Youth"

The late Thomas Midgley, Jr., chose the title quoted above for one of the last of his public addresses. In that address he showed, by an analysis of U. S. Patent Office records, that most important inventions have been made by young men, by men between the ages of 25 and 45. The peak of the curve of inventiveness, he showed, comes at age 35. By these facts he illustrated in quantitative fashion what had been known in a general way before, and what holds in other fields of human endeavor as well, namely, that youth is most original and creative.

This circumstance surely suggests that the research laboratory which does not somehow keep on its staff a proper proportion of young men will pay for that failure in reduced productivity. To us in A.S.T.M. also it suggests that if the technical committees of the Society are to have their maximum productiveness they must be made up in *proper part* of young men.

That it is important to have a suitable proportion of young men on the committees of the Society has been pretty generally realized, to be sure. But the reason often given for it is that the young men should be there, trained and ready, to take the places of the older men when they drop out. That is true, of course. But it is only part of the truth, and not by any means the most important part. Still more important is the fact that the participation of young men in the activities of the Society can determine in large measure its vitality and its productivity.

T. G. Boyd

President

The letter from the Board to the membership points out that economic developments in the few months since the Annual Meeting have still further substantiated the analysis of the situation presented

by the Board in its communication to the members on June 16, 1947, and have made all the more necessary the increased financial support from membership dues.

The letter's concluding paragraph states, "The Board of Directors is highly gratified that the members have taken this important step, which will go far toward maintaining the Society's financial position on a sound basis. It may rightly be construed as evidence of the value placed by the members upon the work of the Society, and of the determination of the membership, which includes so large a part of industry, to give adequate support to that work."

In addition to this amendment of Article VIII, Section 1, which relates to dues, there was also approved another amendment affecting Article III concerning the nomination of officers. This advances the date for transmitting to members the form for recommending members on the Nominating Committee for action by the Board in appointing the Nominating Committee.

Revised Prices on Separate Copies of Standards

THE steadily increasing number of specifications and tests which aggregate more than sixteen pages has led to a study of costs, and this has resulted in a change in the long-established price for copies of standards in separate pamphlet form. For many years the standard price of 25 cents per copy has been in effect, whether the item was two pages or forty pages, but in order to bring these prices more in step with the cost picture, it has been decided that for standards over sixteen to thirty-two pages inclusive the charge will be 35 cents per copy and over thirty-two pages, 50 cents per copy. These prices apply in quantities of one to nine.

The new price scale for separates is summarized as follows:

IN LOTS[1] OF 1 TO 9:
- 1 to 16 pages—25 cents each
- 17 to 32 pages—35 cents each
- Over 32 pages—50 cents each

QUANTITY PRICES:
- 10 to 24—20 per cent discount from above prices
- 25 to 99—30 per cent discount from above prices
- Over 100—special quotation

[1] Lots may consist of the same or assorted standards.

The List of Standards to be issued will indicate items where the charge of 35 cents or 50 cents applies.

Reference Standards:

A new practice also is being employed on furnishing so-called "reference" standards. A number of the specifications refer to other standards, usually test methods, and in the past it has been the custom in many instances to supply these reference standards. Thus, the person who wanted a copy of a specification for a given material would get that item and perhaps six, eight, or ten other standards covering various methods of test. It is recognized, however, that for certain uses only the basic document is needed. Accordingly, from now on, a special return form will accompany each order and those who wish to procure reference standards may request a set without charge.

Selection of Nominating Committee

THE large number of recommendations on members who might serve on the Nominating Committee to submit nominations for officers for 1948–1949 have been tabulated by the Committee of Tellers consisting of Dr. P. H. Dike, Assistant Director of Research, Leeds & Northrup Co., and L. Drew Betz, General Manager, W. H. & L. D. Betz. At its meeting in January the Board of Directors will appoint the Nominating Committee, the personnel of which will be announced in the January BULLETIN. This committee will meet in the early spring and the slate of officers selected will then be referred to the membership for vote.

Beginning in 1948 the mechanics of recommending and appointing a Nominating Committee will be advanced several months so that the Board of Directors can take action at its September meeting.

Twenty-five Years of Australian Standards

ON NOVEMBER 2, 1947, the Standards Association of Australia celebrated its 25th Anniversary. The American Society for Testing Materials has extended congratulations to this organization which has achieved a notable record of service in Australia. The Association has been interested in A.S.T.M. work for many years and it has been a member of the Society since 1928 with W. R. Hebblewhite, chief executive officer as the representative.

During the period of the war, and subsequently, a number of Australian A.S.T.M. members and others from Australia interested in its work have called at A.S.T.M. Headquarters. The Staff is pleased to greet any of its members and friends from Australia.

President Boyd Injured

THE many friends and committee associates of the Society's President, T. A. Boyd, will be sorry to learn that on Tuesday, November 4, he had a bad fall in Detroit at his home and suffered a fractured arm and ankle. While this will keep him out of circulation for some weeks, he was discharged from the hospital after a relatively short stay and he is making satisfactory progress. This accident called for some rearrangement of district meetings because he was scheduled to address sessions in Chicago, Philadelphia, and St. Louis in November and December. Each of these meetings was postponed and it is hoped they can be scheduled for early 1948.

Recently Mr. Boyd's position with General Motors Research Laboratories was changed from that of Head of Fuel Department to Research Consultant, in which capacity he has undertaken some special assignments for the company.

Prior to his accident he had been in Texas where he addressed the manufacturing and research executives of the Socony-Vacuum Oil Co.

Offers of Papers for 1948

THE Administrative Committee on Papers and Publications will meet early in February to consider the papers to be published by the Society in 1948 to develop the program of the 1948 Annual Meeting to be held in Detroit, Mich., June 21–25. All those who have in mind offering papers for presentation at the Annual Meeting and publication by the Society should send these offers to Society Headquarters no later than February 1.

All offers should be accompanied by a summary which should make clear the intended scope of the paper and indicate features that, in the opinion of the author, will justify its inclusion in the Annual Meeting program and publication by the Society. Suitable blanks to be used in transmitting the desired information will be sent promptly on request.

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
1948		
Feb. 2 3, 4,	Committee A-1 on Steel	Philadelphia, Pa.
Feb. 3	PHILADELPHIA DISTRICT (Metals)	Philadelphia, Pa.
Feb. 9, 10, 11, 12	Committee D-2 on Petroleum Products and Lubricants	Washington, D. C.
Feb. 17	NEW YORK DISTRICT (Crystals)	New York, N. Y.
Feb. 24, 25	Committee D-9 on Electrical Insulating Materials	Dayton, Ohio
Feb. 25, 26, 27	Committee D-20 on Plastics	Dayton, Ohio
Feb. 26, 27	Committee C-1 on Cement	Denver, Colo.
Week of March 1	A.S.T.M. Committee Week	Washington, D. C.
Week of June 21	1948 Annual Meeting and Exhibit of Testing Apparatus	Detroit, Mich.

Acoustical Materials

WHAT is the extent of interest in acoustical materials? A conference will shortly be called to consider this question and whether the need for work on standard test procedures and specifications for acoustical materials is such as to warrant the organization of a new A.S.T.M. committee. The suggestion has been made from time to time that work in this field should be undertaken similar to that carried on by our committee on thermal insulating materials. The two types of materials are closely allied but if there is need for work on acoustical materials, a separate committee on the subject would seem to be indicated.

All those interested in this subject who would wish to participate in the proposed conference are asked to get in touch with A.S.T.M. Headquarters.

Tentatives Adopted as Standard Without Change Not to Be Published

A NEW policy is announced in connection with the publication of tentative specifications and tests adopted in 1947 as standard, without any change. These items will not be republished in the 1947 Supplement, but stickers will be issued with these Supplements to all members and purchasers, so a note can be put on the respective standard in the 1946 book, calling attention to the fact that a particular item, formerly tentative, has been adopted, but is not being republished. The Committee on Papers and Publication, felt that the considerable expense involved might well be foregone with a very minimum of inconvenience.

Of course, all specifications and tests adopted as standard in 1947 *with revisions*, will be published in the Supplements so that the latest version is provided.

All of the actions on tentatives and standards covered in the letter ballot which was canvassed on October 15 were approved. This letter ballot listed 109 existing standards which were to be revised and 70 tentatives to be adopted as standard.

DISTRICT ACTIVITIES

Detroit District Meeting on Petroleum

A DINNER meeting of the Detroit District was held on the evening of October 8 in the Rackham Building. About 250 persons were present at the dinner, while attendance at the technical session was over 320. Two interesting papers were given at the session on the subject "Petroleum Products as Related to Automotive Equipment."

District Chairman V. M. Darsey presided at the dinner and introduced President T. A. Boyd, who described the extent and the value to industry of the committee work of the Society, using as an example the activities and publications of Committee D-2 on Petroleum Products, currently meeting in Detroit.

The Executive Secretary, on invitation by the chairman, followed the same subject further by giving a sample preview of the extreme variety of committee activities scheduled for the coming month. He pointed out that in order to stay alive, the Society must continue to grow, and that the continual broadening of the scope of the Society's committee activities and of their contribution to the national economy inevitably involved an ex-

panded publication program.

In order to keep this publications program from growing too unwieldly it will be necessary to change many procedures; consideration may be given to regularly condensing papers to be published, and it may prove advisable to reorganize procedure on receiving and acting on committee recommendations on standards.

Secretary Warwick also described the consolidation of the various corrosion activities of the Society and the elimination of corrosion test sites which duplicate each other. The Committee on Simulated Service Testing was pointed out as another of the newer administrative committees of the Society. He also mentioned the organization of a committee to work with the Ordnance Division of the War Department, and the activation of one group to study and standardize "sandwich type" composite structural materials and another which had issued the radiographic standards developed for the Navy.

In closing, he referred to the 51st Annual Meeting to be held in Detroit during the coming year (June 21–25, 1948), and expressed his expectation of a large attendance.

Mr. T. H. Risk, of Ethyl Gas Corporation, and Mr. H. R. Wolf, of General Motors Research Division, presented prepared discussions of the papers presented by Messrs. Holaday and Larson, respectively. Because of the lateness of the hour, Mr. H. C. Mougey, who introduced the speakers, was then forced to call the meeting to a close.

E. T. JOHNSON

NOTES ON TECHNICAL PAPERS

In the technical session C. M. Larson, Chief Consulting Engineer, Sinclair Refining Co., New York, discussed "Petroleum Lubricating Oils as Related to Automotive Equipment," and W. M. Holaday, Director, Socony-Vacuum Laboratories, New York, covered "The Efficient Production and Utilization of Motor Gasoline."

Although it is expected these two papers will be published as a special technical publication, a few notes on the papers are given here.

W. M. Holaday

C. M. Larson

Lubricating Oils:

In his paper on Petroleum Lubricating Oils, Mr. Larson stressed the complexity of lubricating oils, showing that the carbon atoms can be arranged in a great many different ways, with potential hydrocarbon compounds in, say, an SAE 30 motor oil range, totaling millions. He stated that laboratory tests are not safe guides to service performance and, further, that in most instances the best refined oils need additives of some kind to meet service requirements now imposed. He described some of the additives used and the function they serve in the lubricant. For example, organic amine is added to increase the resistance of oil to oxidation, while a high molecular weight polymer is used to reduce the pour point so that it will pour freely at lower temperatures.

He reviewed the more important service requirements of automotive lubricating oils and some of the problems involved in evaluating the needs and how to meet them. In his conclusion he stressed that our knowledge of the mechanism by which hydrocarbons and additives function is very limited. Until we get more fundamental, factual knowledge about the material called lubricating oil, we will have to depend upon the costly, unwieldly service performance specifications. The separation of more pure hydrocarbons now being carried out through API projects; the eventual oxygenation of pure hydrocarbons so as to understand their oxidation stability and their reactions into various corrosive acids, and the spectrums of such pure hydrocarbons so that narrow lubrication cuts can be identified or classified by mass spectrum analysis, will help our understanding of the problems. Only through the automotive and the petroleum industries' joint efforts can such a huge program be carried out. It is beyond the resources and man power of any one company or industry.

Motor Fuels:

Mr. Holaday's paper incorporated a great deal of information and data, much of it of relatively recent origin. He attempted to present a general picture of the past trends and present factors involved in finding, producing, and refining petroleum, and in the utilization of motor gasoline. The economic utilization of petroleum for transporation is not solely a problem of producing high octane number fuels and adapting engines to use these fuels, but is one which also involves the economics of the entire petroleum industry. If the automotive and petroleum industries are to perform their duty to society, engines and fuels must be provided which will result in the most economical transportation with the lowest consumption of our natural resources.

He reviewed the current status of the petroleum industry and then considered some steps that might be taken to obtain the most economical utilization. At the outset he stressed that there is "no immediate shortage of petroleum" and that "our known reserves are larger today than in any other time." He also stated that the abundance of natural resources in this country in

the past when we lived in a "Land of Plenty" has created a requirement for performance and convenience that doubles the work of the engineer to apply economic considerations and still provide the luxuries that we are so used to taking for granted.

Some of the points he noted in his conclusion are as follows: It is believed that the octane number level of motor gasoline will not increase at as fast a rate as it has in the past because of the huge expenditures that must be made over the next several years to increase production and refining capacity to meet quantity demands.

Higher octane number levels can and will be made available in the future.

To provide an economical advantage to the consumer, the savings in fuel consumption as a result of increases in compression ratio must be more than sufficient to offset the additional cost of the improved gasoline.

It seems apparent that any design which leads to fuller utilization of of the octane number over a greater percentage of the operating time than do the present vehicles, will result in improved economy.

It is believed that the adoption of a dual fuel system, wherein a fuel of high antiknock value is used only during that small percentage of time that the engine is critical in its requirement, would result in more efficient utilization of the country's natural resources and simultaneously extend the ability of the presently installed refining equipment to fulfill vehicle requirements. Also, as another alternative, the development by the automotive industry of improved torque converters, which would enable level road operation at low engine speeds, would have the effect of making fuller use of antiknock quality of present-day gasoline over a greater proportion of operating time and result in improved economy.

Symposium on Flammability and Papers on Textile Fibers Feature Outstanding Meetings in Philadelphia

Philadelphia District and Committee D-13 Cooperate in Technical Sessions

THROUGH the joint efforts of A.S.T.M. Committee D-13 on Textile Materials and the Philadelphia District working through its Council, there were held in Philadelphia on October 16 two very interesting technical meetings, with an informal dinner intervening. The afternoon session, developed by Committee D-13's Subcommittee on Papers and Publicity, headed by R. T. Kropf, Director of Research, Belding Heminway Corticelli Co., New York, featured three technical papers on the subject of flammability. The evening session, arranged for the Philadelphia District by Dr. G. E. Landt, President, Philadelphia Textile Finishers, Inc., Norristown, Pa., and Council secretary, also heard three papers covering various aspects of textile fibers.

The dinner, which had been arranged by the Philadelphia group, with the cooperation of Committee D-13, had as its attraction a most interesting address by S. J. Kennedy, Military Planning Division, Research and Development Branch, Office of Quartermaster General, U. S. Army, Washington, D. C., on the subject of "Textiles for Peace and War."

The programs for the sessions were as follows:

SYMPOSIUM ON FLAMMABILITY

Flammability of Textiles—FREDERIC BONNET, Director, Standards Dept., American Viscose Co., Marcus Hook, Pa.

Flameproofing of Textiles in Theory and Practice—R. W. LITTLE, Director of Research, Ellicott Laboratories, Inc., Lawrenceville, N. J.

The Retailers Viewpoint on the Flammability of Textiles—C. W. DORN, Director, Research Laboratory, J. C. Penney Co., Inc., New York, N. Y.

EVENING SESSION

Cotton Textile Fibers in Various Industrial Uses—B. L. WHITTIER, Sales Engineer, Mt. Vernon-Woodberry Mills, Inc., Baltimore, Md.

Modifications of Textile Fiber Properties Through Finishing Operations—D. H. POWERS, Director, Textile Chemicals Dept., Monsanto Chemical Co., Boston, Mass.

Some of the Newer Textile Fibers, Including Glass, in the Textile Industry—RENE BOUVET, Head, Textile Research Department Branch, American Viscose Corp., Marcus Hook, Pa.

The Philadelphia District Council had not had a technical meeting on the subject of textiles for some years, and when it was determined that Committee D-13 would hold its intensive series of fall meetings in Philadelphia in October, this provided a very opportune occasion for papers in the textile field, and with Philadelphia one of the country's leading textile centers, the district council was anxious to stress the A.S.T.M. activities in this field.

Since it is the plan to publish the Symposium on Flammability, no attempt is made here to present a news account of this session. The subject is one of widespread importance, and there was a large audience in attendance.

Judson F. Vogdes, Jr., Philadelphia District Chairman, presided at the dinner at which there were about 200 present.

At the evening session, Dr. W. D. Appel, National Bureau of Standards, very active in D-13 work, and a Past-President of the American Association of Textile Chemists and Colorists was the presiding officer in the absence of Dr. Landt.

All in all, this series of meetings was considered an outstanding success.

In the material on page 33, an attempt is made to present some of the highlights stressed by Colonel Kennedy and one other speaker at the evening session.

S. J. Kennedy

District Meeting on Textiles in Providence

UNDER the auspices of the New England District Council a most successful district meeting was held in Providence, R. I., on October 30. An interesting technical program on textiles had been arranged featuring three talks on specific aspects of the field. Notes on the program appear below. The technical session held at the Providence Engineering Society Headquarters was preceded by an informal dinner of the District Councilors and the speakers, Messrs. Gibbons, Frain, and Schwarz.

The New England District has held several successful meetings in Boston, but, as a matter of policy, is arranging for sessions in some of the other New England centers. The splendid cooperation accorded the Council by local A.S.T.M. members in Providence, and the attendance of over 150, in spite of bad weather, speaks well for future meetings.

District Program Chairman, Walter C. Voss of M.I.T., with Professor H. J. Ball, arranged with a local program committee to develop the technical session. This local group included the following: K. B. Cook, Crown Manufacturing Co.; W. D. Fales, Dean, Textile School, Rhode Island School of Design; F. G. LaPiana, Stein, Hall & Co.; E. A. Richards, Airedale Worsted Mills; D. C. Scott and D. C. Scott, Jr., Scott Testers, Inc.; and W. H. Whitcomb, Secretary, A.S.T.M. Committee D-13 on Textile Materials. The committee was successful in getting three outstanding technical authorities and executives in the textile field to participate; the program being as follows:

Woven Narrow Fabric and Its Relation to the Textile Industry by Edwin J. Gibbons, President of the Eastern Tape and Webbing Co. and formerly Manager of the Thomas French & Sons, Ltd.; Production Manager of Hope Webbing Co. and Chief Designer of Russell Manufacturing Co. Mr. Gibbons outlined the history of narrow fabrics as related to the types of machines, the use and present production facilities.

Braiding Narrow Fabric and Its Relation to the Textile Industry, by Freeman W. Fraim, Treasurer of Essex Mills, Inc., and formerly Vice-President and Director of Manufacturing for the International Braid Co., and in charge of Technical Development of the Atlantic Rayon Corp. Mr. Fraim discussed the braided fabrics, types of machines, production quantities, products and the need for further work by the A.S.T.M. in developing standards and tests for braids.

New Methods and Techniques of Testing Textile Materials, by Edward R. Schwarz, Professor of Textile Technology, and in Charge of the Textile Laboratory at the Massachusetts Institute of Technology. Mr. Schwarz illustrated by slides the new equipment using electronic devices particularly to control the time element. He also demonstrated a method of rating test data for purposes of determining the degree of correlation.

H. L. Sherman, Chairman of the New England District, presided at the dinner and also opened the technical session. He outlined the aims of the New England District and discussed the work that had been done to date. A telegram of congratulation had been received from the New York District which also was sponsoring a meeting that night, and this was read by the Chairman.

C. L. Warwick, Executive Secretary of the Society, was introduced and spoke briefly on the activities of the several districts and the number of committee meetings being held, as indicating the great amount of interest shown by the members of the Society.

The Technical Chairman of the meeting was D. C. Scott, Jr., who introduced the speakers. Mr. Scott in addition to his aid with the technical program, handled the local arrangements and sending of invitations to members of other societies who would be interested in the meeting. District Secretary Miles N. Clair and Vice-Chairman V. G. the Altieri took an active interest in meeting and attended the dinner.

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300 at New York Meeting on Silicones

AN INTERESTED audience of about 300 members and guests heard an excellent lecture on the subject "Silicones" at the meeting sponsored by the New York District on Thursday, October 30. K. W. Given, Chemical Department, General Electric Co., of Pittsfield, gave an excellent talk and demonstration of these versatile new materials, following which there was an intensive question-and-answer period, when two of Mr. Given's technical associates answered about as heavy a barrage of questions as could be crowded into the discussion period of almost a half hour.

Preceding Mr. Given's talk, greetings were extended by District Chairman Myron Park Davis, followed by a few notes on the importance of research in A.S.T.M. work by Assistant Secretary R. J. Painter. He stressed the fact that in the Society research and standardization go hand in hand, and that a workable specification or a satisfactory test method must be based on the best present knowledge of materials involved. The Technical Chairman was R. D. Bonney, of Congoleum-Nairn, Inc. Mr. Bonney, a long-time active A.S.T.M. member, is at present Chairman of the important Administrative Committee on Standards. In the audience were a large number of

Kingsley W. Given

men from the paint, varnish and related industries, the plastics field, and others.

A résumé of Mr. Given's talk follows:

About 76 per cent of the earth's crust is composed of silicon and oxygen. Sand is an example of this combination. During the war many new and useful products made from silicon were developed. They are called silicones.

Silicone products take various forms—oils, greases, resins, rubber, water-repellent film, etc. Resistance to heat, moisture, and to other chemicals are their outstanding characteristics. So silicone oils and greases will stand great heat—and cold, too. They enable us to have a fluid that will flow at temperatures as low as −121 F. Silicone liquids used for airplane hydraulic systems won't get thick in low temperatures and thin in high temperatures. So piping can be smaller, less liquid is needed, and there's less danger of leakage. Silicone greases are excellent for lubricating plug cocks in large chemical industries. Unlike petroleum greases, silicone greases are resistant to oxidation, remain stable at elevated temperatures, and are not affected by most chemicals.

Ordinary rubber if heated to 300 F. for 24 to 36 hr. would become hard, cracked, and brittle. Silicone rubber that has been baked that way for a year would still remain pliable.

Many big war planes had turbosuperchargers which needed gaskets. These gaskets had to take the punishment of white heat on the inside and stinging cold on the outside. And they had to remain resilient and pliable. Silicone rubber was ideal for this purpose. Searchlight gaskets must remain pliable at temperatures running from − 40 to +340 F. This silicone rubber gasket material is the only kind that would meet military specifications.

A laboratory curiosity came out of one of the many rubber research projects. This looks like taffy, it pulls like taffy, but it doesn't get hard like taffy. By rolling this peculiar material into a ball and throwing it on the floor, we get a surprising reaction. This is called bouncing putty. This is *not* silicone rubber. So far the only use found for it is in exercising injured hand muscles. Some veterans' hospitals are using it for such exercises. But it will never be used for putty—that is, not until it stops lying down on the job when left alone. As soon as you stop pushing and pulling this material it will begin to slump.

Silicones can also be converted into resins. These resins are used to make varnish, enamels, and paints which are used to finish refrigerators, stoves, laundry and dairy equipment, hospital equipment, etc. Silicone varnish and other silicone finishing materials resist acids, alkalies, water (fresh or salt), oils, and they weather very well. The enemies of appliance finishes—fruit juices, iodine, and animal fats—have no effect at all on silicone finishes. Because of the ability of the silicones to resist heat, white finishes, such as on ovens, will not discolor even when subjected to temperatures of 485 F.

Silicone resins are also used to produce a glass laminate. Layers of glass cloth soaked in silicone resin are stacked in a press between smooth, hot steel plates. When such a pile is subjected to heat and pressure a glass laminate is produced. Our plastics laboratory people placed a piece of this in an oven heated to 250 C. At the end of a week the mechanical and electrical properties were better than they were at the beginning. Electrical apparatus equipped with this kind of insulating material may bring about a change in our thinking. Instead of wondering how much heat the apparatus will withstand before the insulation breaks down, we may wonder how much heat it will stand before the copper begins to anneal.

Still another product made from silicon is a water-repellent film. Surfaces exposed to the vapor rising from this liquid become water-repellent.

A film-treated blotter or a film-treated filter thimble will repel water. Why? Because the vapor from the liquid combines with moisture on the surface to be treated to form a sub-microscopic, water-repellent film on that surface.

A dive bomber or a fighter plane flying very high in the air suddenly goes into a dive for some reason. We've all seen people who wear glasses step into a warm room on a very cold day. Quickly a mist covers the lens of the cold spectacles. That's just exactly what can happen to cold radio and radar insulators suddenly dropping into warmer atmosphere. And a coating of condensed vapor on insulators is dangerous. Insulators treated with this film shed water. What little water clings to the surface of treated insulators stands up in tiny beads, leaving dry spaces between the beads that high frequency currents can't jump.

Other materials and objects can be made water repellent. Windshields, camera lenses, and other optical surfaces can be treated so that rain, mist, and other moisture will not obscure vision. Textiles and paper can be made water repellent.

This was the first meeting sponsored by the New York District, with three others in prospect: one on December 9 to cover Induction Heating and Electronic Cooking; a third in February, with a discussion of Work on Crystals, at Bell Telephone Laboratories, and an address by President T. A. Boyd; and a potential fourth meeting sometime in March or April, subject to be announced.

Pittsburgh Meeting on High-Strength Steels

DESPITE other competing events, including the last-minute opening of the Pennsylvania hunting grounds by the Governor, a successful meeting was held under the auspices of the A.S.T.M. Pittsburgh District at Mellon Institute on October 31, with H. Malcolm Priest, Manager, Railroad Research Bureau, U. S. Steel Corp. Subsidiaries, giving an interesting paper on "High-Strength Steels." In his address, which was accompanied by some well-selected slides, Mr. Priest answered the questions "Why? How? and Where?" with respect to these materials. This type of steel is in the nature of a low alloy with rather low-carbon content and usually involving manganese on the high side, with such elements as copper, chromium, nickel, molybdenum, phosphorus, and silicon. The yield points of these steels run considerably higher than normal A.S.T.M. structural

G. H. Priest

steel, Specification A 242 for high-strength steel, for example, providing for a minimum yield of 50,000 psi. in thicknesses up to $\frac{3}{4}$ in. With the normally low-carbon content, no special handling is required in welding. This method of fabrication results in additional weight saving, this saving in weight being one of the important attributes of this class of steels. Mr. Priest described the various uses of the steels in railroad freight cars and other equipment of this kind, in the automotive truck and tractor industry, in mine cars, and in other structural applications. Final choice of these steels, which came into use about 1933, with the tonnage increasing rather steadily since that time, is dictated by the usual factors involved in the design problem, namely, first cost, the cost based on service life, and operation and maintenance savings. Most of the steels are characterized not only by saving in weight but also resistance to atmospheric corrosion.

J. J. Bowman, Chairman of the Pittsburgh District, presided at the meeting.

Buffalo District Has an Interesting Program

Two very interesting talks on "Paint, the Servant of Industry" and "Recent Developments in Portland Cement" featured the November 18 meeting sponsored by the Western New York–Ontario District in Buffalo. Following an informal dinner, the technical session was held with District Chairman Thomas L. Mayer, Buffalo Public Library, presiding. He introduced A.S.T.M. Vice-President J. G. Morrow, Steel Co. of Canada, who extended greetings for the Society and gave a short but interesting talk on the establishment of A.S.T.M. and how it is achieving its purposes. The two technical talks were presented by W. H. Lutz, Technical Director, Pratt & Lambert, Inc., who spoke on paint, and J. F. Barton, Chief Chemist, The Federal Portland Cement Co., who discussed his field.

These two talks implement suggestions that the A.S.T.M. Districts might wish to have some of their officers and members present thumbnail sketches of the particular industries in which they are active. As the first of these talks, Messrs. Lutz and Barton gave an excellent picture of their industries and technical developments. Abstracts of the papers they presented are to appear in the January BULLETIN.

J. F. Barton

W. H. Lutz

A.S.T.M. Participates in the Pacific Chemical Exposition

THE Society participated in the 1947 Pacific Chemical Exposition and Pacific Industrial Conferences held in the Auditorium at the San Francisco Civic Center, October 21–25, 1947. Booth space advantageously near the main entrance was donated by the Exposition management. A very complete exhibit of current A.S.T.M. publications was attractively arranged on shelves and a registration desk for members and visitors was set up. Redman Scientific Co. of San Francisco loaned several items of A.S.T.M. standardized test apparatus as an element in attracting attention to the booth.

Attendants in the booth throughout the exposition period volunteered from the local A.S.T.M. membership, several being members of the Northern California District Council. That Council, with some aid from Philadelphia headquarters, carried out the details of arranging the features of the A.S.T.M. exhibit.

The Pacific Chemical Exposition is to be conducted on a permanent basis by the California Section of the American Chemical Society, holding conferences and expositions of chemicals, chemical apparatus, and chemical engineering equipment each second year in San Francisco, thus alternating with the Chicago Chemical Exposition under the same management. The next scheduled chemical exposition and conference in San Francisco will be November 1 to 5, 1949, this coinciding with the celebration of the 100th anniversary of the great California gold rush.

The gate count of attendance at the 1947 exposition and conference was 14,726. The quality of the attendance was declared by several experienced exhibitors to be unusually high. At the A.S.T.M. booth there was a constant flow of callers for the whole ten hours of each day of the exposition period.

While many of those who registered at the booth were already members, the greater number was in the nonmember class. Each of these was interviewed; many had

questions, mostly pertaining to their own problems, concerning A.S.T.M. standards, methods of sampling, testing, and preparation of specifications. Several asked for application blanks for membership.

The Northern California District Council did not participate in the conferences through the medium of presenting papers before any of the several meetings held throughout the week. A Council luncheon was held at the Engineers' Club in downtown San Francisco on the fourth day of the exposition week. Several members and interested visitors at the booth were invited to attend this luncheon which, however, was not formally scheduled.

An interesting feature of the participation was that a small selection of A.S.T.M. publications was loaned to the Special Libraries Association and was included in the very excellent exhibit of that organization.

During the exposition, distribution was made of broadsides and other literature of the Society. One of the most effective of the items given away was the current index to A.S.TM. Standards. In several instances these were given to technicians employed by corporations which already have A.S.T.M. membership but which have only a single copy of the Index and thus not readily available for use by employees.

In the distribution of literature practically none was given unless the recipient was interviewed and his needs specifically ascertained. Because of this, the flood of publications normally gathered by casual visitors at such expositions was not a characteristic of the A.S.T.M. distribution.

In general it was concluded that A.S.T.M. made a good showing at the Pacific Chemical Exposition. Its participation won new friends and justified the esteem of its old friends and members.

NOTE FROM THE EDITOR—

The above account of the Society's participation in the Pacific Chemical Exposition was very kindly prepared by Mr. Dozier Finley, Chairman of the Northern California District. Mr. Finley along with Messrs. G. H. Raitt and P. V. Garin, the District Vice-Chairman and Secretary, respectively, did much of the work in connection with the booth display.

One of the important phases of A.S.T.M. work is to promote among those concerned and interested a better knowledge of what the Society is and does, and particularly to make known just how its standardization and research work is made available to industry and the technical people generally. Displays of A.S.T.M. publications and related items are desirable as promotional channels, and the Northern California Council and the members deserve much credit for their initiative in arranging not only for this display in the Western Chemical Exposition but in the Western Metals Exposition, earlier this year in Oakland.

Meetings in Philadelphia (Feb. 2) on Failure of Metals, and New York, (Feb. 17) on Development of Crystals

THE Philadelphia and New York District Councils have arranged what should prove to be very interesting meetings for early 1948. The meeting in Philadelphia at the Benjamin Franklin Hotel, scheduled for February 3, will feature two addresses on the question of fracture or rupture of metals. One speaker will discuss the subject from a theoretical standpoint, and the other will review the matter from the practical standpoint. Each of the men will be widely recognized as an authority in his field, and an interesting presentation is assured. All A.S.T.M. members and others concerned are invited. The Philadelphia meeting is being held during the three-day series of meetings of Committee A-1 on Steel, February 2 to 4, incl. It is expected that a dinner will be arranged preceding the technical session.

The New York meeting will feature a subject that has been rather widely publicized in the technical and popular press by Bell Telephone Laboratories in their interesting advertising program. This involves the growth of crystals in the laboratory. While, normally, plates of

quartz were used in the electric wave filters of coaxial circuits and in other applications, the supply is limited and the cost so high that the impending shortage would be very serious. Foreseeing this situation the Bell Telephone Laboratories devoted intensive study to "growing" synthetic crystals, and they now can replace quartz. This remarkable development will be described by A. C. Walker of the Laboratories who had a leading part in the work. Preceding the address there is to be a short talk on research by an outstanding administrator in this field. The meeting is scheduled for the Engineering Societies' Building, 29 W. 39th St., New York City, beginning at 7:30 o'clock sharp, the night of February 17. The New York District Council will be glad to welcome anyone interested in this work.

Technical Papers Published in Advance of *Proceedings*

A NUMBER of the technical papers listed in the October ASTM BULLETIN, page 10, which it was announced would be made available as separate reprints well in advance of the 1947 *Proceedings*, have come off press and are being distributed to those who sent in their orders for the papers. The eight papers now available cover the following:

(AP 1) Fatigue Characteristics of Copper Alloys (Burghoff and Blank)
(AP 2) Creep Characteristics of Copper and Copper Alloys (Burghoff and Blank)
(AP 4) Fatigue Characteristics of Steel and Aluminum Alloys (Fuller and Oberg)
(AP 7) Evaluating Triaxial Shear Tests on Earth Materials (Holtz)
(AP 8) Polarographic Determination of Tetraethyl Lead in Gasoline (Borup and Levin)
(AP 10) Thermal Diffusivity of Granular Materials (Shannon and Wells)
(AP 12) Steel for Tubular Products (Wilder)
(AP 13) Determination of Soft Pieces in Aggregate (Woolf)

Those members who have not procured these papers can send their orders to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa., either using the order form in the OCTOBER BULLETIN or by letter. The remaining several papers are in preparation and it is expected will be available within the next few weeks.

Committee A-6 Approves 25-cm. Test Frame for d.-c. Testing

AT THE June meeting of Committee A-6 in Atlantic City, it was recommended that the following notice be brought to the attention of the Society: "The 25-cm. Epstein Test Frame described in Section 22 of Methods A 34 – 46 can be used for d-c. testing at inductions above 10 kilo-gausses, using 88 cm. as the effective length of the magnetic circuit."

1948 AFA and ASM Meetings in Philadelphia

PHILADELPHIA will be very much in the spotlight in 1948 with respect to the meetings of national technical and engineering groups. The American Foundrymen's Association will hold its 1948 convention and exhibit at Philadelphia's Convention Hall, during the week of May 3 to 7, and it has been recently announced that the American Society for Metals and the other affiliated groups will hold the National Metal Congress in Philadelphia October 23 to 29 of next year. Another Philadelphia meeting and exhibit is the Instrument Society of America scheduled for September 13 to 17.

TECHNICAL COMMITTEE NOTES

Wires for Electrical Conductors

SINCE the activities of Committee B-1 were last reported in the August BULLETIN, the committee itself has held no meetings but several of the subcommittees made a good start on their program of activities for the current year at meetings held in New York City recently.

On September 16 the Subcommittee on Conductors of Light Metals, of which P. V. Faragher is chairman, met and reviewed the first drafts of specifications for hard-drawn aluminum wire, for aluminum cable, and for aluminum cable steel, reinforced (A.C.S.R.). This is the first time that any A.S.T.M. committee has formulated specifications for these materials and the meeting was well attended and considerable progress made. It is expected that the subcommittee will meet again in the near future, at which time the three specifications will be put in final form for submission to letter ballot.

On the following day, also in New York, the Subcommittee on Composite Conductors of Copper and Steel, of which C. E. Ambelang is chairman, met and reviewed the initial drafts of a number of other new specifications which fill out the program for the new materials now covered by the enlarged scope of Committee B-1. Initial drafts were presented on specifications for copper-covered steel wire of three grades, representing 30 per cent conductivity of high strength and extra high strength and 40 per cent conductivity. Initial drafts were also presented of specifications for copper-covered steel and copper composite conductors; on concentric-lay-stranded copper-covered steel conductors; and on copper and steel composite conductors. A number of suggestions for changes in the proposed drafts were made at the meeting and revised drafts will be presented to the subcommittee.

The Subcommittee on Conductors of Copper and Copper Alloys, of which H. H. Stout, Jr., is chairman, met on October 30 and considered a number of subjects. The most important of these concerned the status of the well-known circular No. 31 of the National Bureau of Standards—the copper wire tables (the "bible" of the electric power and light industry). The subcommittee was advised that this circular is again out of print (it was reprinted ju[illegible] a short time ago) and

there was some question as to whether it would be reprinted. All members of the committee present promptly recommended that it should not be allowed to go out of print. It was also noted there may be some revisions in the new edition, and the committee, after careful consideration, made some eleven recommendations which will be passed on officially by Committee B-1 to the National Bureau of Standards for consideration.

Other items discussed at the meeting of the Subcommittee concerned proposed revisions in the bend test requirements in the Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors (B 48 – 45); tensile elongation requirements for individual wires removed from soft stranded cable covered by Specifications B 172, B 173, and B 174; and minor changes, largely of an editorial nature, in a number of other specifications.

Committee B-4 on Electrical Heating, Resistance, and Related Alloys Meets at A.S.T.M. Headquarters

COMMITTEE B-4 held its fall meetings at A.S.T.M. Headquarters in Philadelphia on November 11, 12, and 13. Incidentally, these meetings comprised the largest group of meetings both as to number and attendance which has been held at Headquarters since the Society moved into its own Headquarters building.

The first two days of the meetings were largely concerned with a review of the status of the project on evaluating the emissivity of cathode nickel, and other activities of the Subcommittee on Metallic Materials for Radio Tubes and Incandescent Lamps. At the meeting of the Data Subsection, eight companies presented their test results on Melts 72 through 76 in comparing them with Melt 66 which currently is being used as the standard. Very good agreement on the data from different companies is now being attained. The Diode Subsection is studying intensively conditions for life tests and the subject of test voltages. The Chemical and Metallurgical Subsections met jointly and the Section on Physical Testing completed recommendations on proposed changes in Methods of Testing Sleeves and Tubing for Radio Tube Cathodes (B 128 – 42). The Section on Particle Size and Density of Powder has agreed upon a statistical approach to the evaluation of particle size which they feel is the answer to this important problem. Methods for the tensile testing of fine wire were discussed and arrangements made to have papers written summarizing the work of the Radio Section to date. It is hoped that these will be ready for publication in the BULLETIN sometime in the spring.

The Subcommittee on Electrical Tests is preparing a complete review and revision of the Method of Test for Resistivity of Metallic Materials (B 63 – 36).

The Subcommittee on Contact Materials also held a well-attended and active meeting and noted that excellent agreement on welding characteristics is now being obtained by the several companies using the A.S.T.M. Contact Testing Machine. Meetings of the Subcommittee on High-Temperature Alloys and of the Subcommittee on Controlled Atmospheres as well as of the Advisory Committee and of Committee B-4 rounded out the full program of the meeting for this session of the committee.

Mr. Stanton Umbreit of the Radio Corporation of America was appointed acting assistant secretary of the committee.

Copper and Copper Alloys

COMMITTEE B-5 on Copper and Copper Alloys and most of its subcommittees held a series of meetings in Pittsburgh at the William Penn Hotel on November 5, 6, and 7, with Chairman G. H. Harnden of the General Electric Co. presiding.

The Subcommittee on Plate, Sheet, and Strip appointed a task group to examine the need for, and if advisable prepare, a specification for aluminum bronze boiler plate. The subcommittee also voted to make minor changes in chemical composition for some of the alloys in the Specifications for Brass (B 36 – 46 T) and Leaded Brass (B 121 – 46 T), Plate Sheet and Strip. The Subcommittee on Rods, Bars, and Shapes voted to delete from all specifications straightness tolerances for shafting and piston finish rod, since no satisfactory method of measuring this requirement has been found. Minor changes were also recommended in the tolerance tables in the Specification for Copper Bus Bars, Rods, and Shapes (B 187 – 46 T) and it was also voted to restore requirements for raw materials in this same specification. Minor changes were also recommended in the table of chemical composition in the Specifications for Copper and Copper-Base Alloy Forging Rods, Bars, and Shapes (B 124 – 46). The Subcommittee on Wire and Wire Rod is recommending minor changes in the composition of Alloy 7 in the Specification for Brass Wire (B 134 – 46) and is considering writing a new specification for hard copper flat wire.

The Subcommittee on Pipe and Tubes voted to recommend minor changes in the table of chemical composition in the Specification for Copper and Copper-Alloy Seamless Condenser Tubes (B 111). Task groups in this subcommittee are working on the problem of size limitations for Rockwell tests on tubes and the determination of hardness and temper of copper tubes.

The Subcommittee on Castings and Ingots for Remelting did not meet in Pittsburgh but presented a progress report on actions pending in the committee which are expected to be completed by the time of the spring meeting. One of the most

important of these is the organization of a test bar task group which met in Washington on December 2 to review this problem.

The Subcommittee on Methods of Test is currently one of the most active groups in the committee and it has several task groups working on important problems. One of these is studying the effect of speed of testing, on which a final report is expected in the spring. A second task group, studying the tension testing of thin sheet metal (0.010 in. and less in thickness), made a final report and presented, for the consideration of the committee, a proposed method of test. The relation between Rockwell hardness and thickness of stock tested is being studied cooperatively by tests being conducted in eleven laboratories. Very good progress has been made to date and it is hoped that this work will be completed by the spring. The subcommittee also considered at length the objections raised by a member casting a negative vote this year on the Method of Tension Testing of Copper and Copper Alloy Rods, Bars, and Shapes (B 220 – 47 T). These concerned chiefly the question of reducing the area of specimens between gage marks, and agreement was reached on a revision which will be submitted to letter ballot in the subcommittee.

The Editorial and Publications Subcommittee is continuing its study of the correlation of chemical limits and of the nomenclature and classification of wrought alloys under the jurisdiction of the committee.

Arrangements were also made to set up a small conference committee with representatives of Committee E-3 on Chemical Analysis to confer on problems of mutual interest regarding the sampling of copper base alloys.

Record Attendance at Four Constructional Material Committee Meetings in Chicago

Program Included Inspection Trip of Long-Time Concrete Tests

EVIDENCE of the postwar return to "full-speed-ahead" activities of several A.S.T.M. technical committees in the construction field was clearly demonstrated at a group of committee meetings at the Palmer House in Chicago during the period November 3 to 6, inclusive. According to the statements of committee officers, the group meetings of four constructional materials committees, namely, C-1 on Cement, C-7 on Lime, C-9 on Concrete and Concrete Aggregates and D-4 on Road and Paving Materials, were among the best attended on record. This applied not only to the main meetings but also to the subcommittee attendance and the number of subcommittees holding meetings. A total of 56 meetings took place in this period. In addition, meetings were held by two sectional committees organized under the procedure of the American Standards Association, namely, Sectional Committee on Specifications for Portland Cement, A1; and Sectional Committee on Road and Paving Materials, A37.

A closing feature of the meetings was an inspection trip conducted by the Portland Cement Association to their Naperville Farm experimental station. This was the first open inspection of the long-time concrete tests being conducted by the P.C.A. covering an extensive series of weathering tests, now over five years old, on a variety of portland cements in varying combinations with aggregates from several sources.

Immediately preceding the A.S.T.M. committee meetings, an all-day session was held by the Materials Committee of the American Association of State Highway Officials.

Cement:

Committee C-1 on Cement held a most enthusiastic meeting on the morning of November 5. An attendance of 77 members out of a voting membership of 86 was present with approximately 30 visitors in addition. Previous to the main meeting, a series of 17 subcommittee meetings were held which included all but two subcommittees. However, *all* subcommittee chairmen submitted reports covering phases of the work. Much of the content of the reports was in the nature of progress which shows promise of the submission of recommendations on standards by the time of the next meeting. This meeting has been scheduled to be held in conjunction with the Annual Meeting of the American Concrete Institute in Denver, Colo., during the week of February 23, 1948.

Lime:

Committee C-7 on Lime opened the series of A.S.T.M. committee meetings on November 3. Four of the six subcommittees held well-attended meetings. The highlights of the resulting reports included the decision of the Subcommittee on Methods of Test to form two sections within their membership to deal with physical and chemical test methods, respectively. The Subcommittee on Lime for the Chemical Industries presented a concise program of work which will consist of preparing four new tentative specifications for the use of lime in water treatment—other than softening—carbide leather, and grease, respectively, and in addition, one revision covering the present specification for lime for water treatment. The Research Subcommittee will consider as its first problem the matter of the soundness of lime with the Subcommittee on Hydraulic Lime expressing its intention to work toward a soundness test method. Mr. Hakanson of the Skanska Cement Co., Sweden, was introduced as a visitor. The next meeting of Committee C-7 will be held during the 1948 Annual Meeting of the Society in Detroit.

Concrete and Concrete Aggregates:

Committee C-9 on Concrete and Concrete Aggregates held meetings of 14 of its subcommittees and the main committee. Similar to Committee C-1, these meetings were marked by a record attendance of more than 110 members and visitors. These sessions were the first since the reorganization of Com-

mittee C-9. The general reaction was one of enthusiastic endorsement of the new type of organization which now consists of three groups of small subcommittees concerned with administrative, research, and test method and specification functions, respectively. Among the many items reported on by the subcommittee chairmen, only one or two are cited here. Research will be directed toward the formulation of methods for determination of shale and for soft particles in concrete aggregates; a new tentative specification will be prepared covering light-weight aggregates; and it is expected that a test method will be presented at the next meeting on the measurement of bleeding in concrete. Details for the exact time and place of the next meeting, which is contemplated some time next spring, were left for decision to the committee officers.

Road and Paving Materials:

Committee D-4 on Road and Paving Materials concluded the series of A.S.T.M. meetings with 16 subcommittees meeting on November 5 followed by a main committee session on the 6th. An attendance of over 70 at the main meeting again gave evidence of the intensive interest in this work. Most reports stressed programs for the immediate future with action expected in many instances by the next meeting. An example of this is a proposed revision of the new tentative specification for hot-mixed, hot-laid asphaltic concrete base and surface courses.

Sectional Committees:

Meetings were held in conjunction with the A.S.T.M. meetings by Sectional Committee on Specifications for Portland Cement, A1, and Sectional Committee on Road and Paving Materials, A37. Sectional Committee A1 met as a reactivated committee for the purpose of taking action on certain standards on portland cement. Action was taken at this meeting recommending approval by the American Standards Association as American Standard of: A.S.T.M. Specifications C 150, C 175T, and C 91; and A.S.T.M. Methods of Test C 109, C 114, C 114T, C 115, C 150, C 183, C 185T, C 186, C 187, C 188, C 189, C 190, and C 191. In addition, action was taken proposing that the differences in the present portland cement specifications as prepared by the Federal Specifications Board, American Association of State Highway Officials and the American Society for Testing Materials be compiled and sent to the respective organizations for the purpose of encouraging the reconciliation of existing differences.

Sectional Committee A37, in its first meeting since 1942, took action on a series of recommendations covering both A.A.S.H.O. and A.S.T.M. standards for adoption as American Standard. All existing A.S.A. standards under the jurisdiction of the committee were either reaffirmed or revisions were recommended for adoption. In addition, an extensive list of standards compiled from a study made of A.A.S.H.O. and A.S.T.M. standards were reviewed and selections made for recommendation for approval as American Standards. Further study will be given to standards of other national organizations covering road and paving materials for further consideration by the committee.

Paper Products Committee Forms Research Group

THE Advisory Committee and two subcommittees of Committee D-6 on Paper and Paper Products met at the Ten Eyck Hotel in Albany, N. Y., on November 7. Perhaps the most significant development resulting from the advisory group meeting was the decision to form a new subcommittee on research. It was felt by all members present that there would be many problems of a research nature where this new subcommittee can materially assist, both in the initial organization and also in correlating with the other working subcommittees. One project already suggested pertains to the development of a stiffness test. A decision was also reached to change the title of Subcommittee IV from Fiberboard and Fiberboard Containers to Container Board. This is in line with the transfer of jurisdiction on all standards pertaining to the complete container as a finished product to Committee D-10 on Shipping Containers.

Subcommittee I on Paper Testing Methods transacted a considerable amount of business during a morning meeting. Among the several test methods discussed were several new ones on which action was taken to refer them to letter ballot including a proposed Tentative Method of Determining Reducible Sulfur in Paper; a Method for Determining the Chloride Content in Paper; Method of Testing Filter Papers; Method of Measuring the Stretch of Paper; and a revision of the Method of Testing Ply Adhesions (D 825).

The newly organized Subcommittee III on Specifications held its first meeting during the afternoon. The first assignment of this subcommittee will be to prepare a specification on analytical filter paper. A meeting of the Main committee will be held on February 27, in New York City in connection with the Annual Meeting of T.A.P.P.I.

Activities on Plastics and Electrical Insulating Materials

Much Research and Standards Work Being Handled

THE THREE-DAY joint meetings of Committees D-9 and D-20 held on November 5 to 7, at the Chalfonte Hotel, Atlantic City, with a total attendance of about 200 members and guests were highlighted by the annual D-9–D-20 Dinner.

Electrical Insulating Materials

In addition to the main meeting of Committee D-9 on Electrical Insulating Materials, 25 subcommittees and sections also convened over the two-day period, November 5 and 6.

The Subcommittee on Insulating Varnishes, Paints, and Lacquers completed a reorganization of its activities which will now be carried on under four subdivisions on oxidizing, heat-reactive, laminating, and high-temperature varnishes. Revisions were approved in the Tentative Methods of Testing Varnishes Used for Electrical Insulation (D 115) which will make more specific the requirements for preparation of test specimens and will eliminate the procedures for volatile matter by volume and the test for dielectric strength of varnish in the liquid state.

The Subcommittee on Plates, Tubes, Rods, and Molded Materials reported the completion of new specifications for cellulose acetate film for primary insulation, and a revision of the Tentative Specifications for Nonrigid Vinyl Chloride Plastics (D 744) providing for the addition of four electrical grades. Both of these items are to be sent to letter ballot of the subcommittee. It was reported that work is to be undertaken on specifications for polyethylene and tetrafluoroethylene. Revisions were considered in the Tentative Specifications for Phenolic Molding Compounds (D 700) and also in the Tentative Specifications for Laminated Thermosetting Materials (D 709), the changes in the latter covering new types of glass base materials and new tolerances on thin laminates. A new Method of Test for Bond Strength of Plastics and Electrical Insulating Materials was given a final review and is now ready for presentation to the Society for publication as tentative. It was reported that a new method for arc resistance using an improved apparatus is actively under way.

The Subcommittee on Liquid Insulation is continuing its many activities and prior to the meeting of the main subcommittee there were sessions of the ten sections of this subcommittee. Agreement was reached at the meeting of the Section on Specifications on the various properties and limits therefor that should be considered in the preparation of screening specifications. These include dielectric strength, acid or base number, sulfur, viscosity, pour and flash points. Plans were made at the meeting for another symposium to be held at the November, 1948, meeting. Action was taken recommending the adoption as standard with revisions of the Tentative Methods of Test for Gas Content of Insulating Oils (D 831), and also the adoption without change of the Tentative Method of Test for Dielectric Strength of Insulating Oil of Petroleum Origin (D 877). There is an active program under way on correlation tests to determine the relation of sludge test values as ascertained by A.S.T.M. Method D 670 with actual service life of insulating oil in transformers. Some twenty laboratories are participating in field tests on transformers at various test locations. While results to date indicate that laboratory tests are able to pick out an inferior grade of transformer oil, these studies will be continued over several more years to obtain operating experience.

The Subcommittee on Ceramic Products is studying procedures for measuring power factor and resistance characteristics of steatite under varying humidity conditions. Methods are in preparation for testing both compression-molded and injection-molded glass bonded mica.

The Subcommittee on Insulating Fabrics reported that its Section on Electrical Adhesive Tapes has virtually finished the development of tests for thickness, adhesivity, breaking strength and shelf aging. Methods for electrolytic corrosion are being studied. The effect of varnishes and solvents on tapes is receiving further study.

The Subcommittee on Insulating Papers reported further progress in its study of methods for conductivity of aqueous extracts of paper, a pH method for vulcanized fiber, and a procedure for determining chlorine in insulating paper. Another section has in preparation purchase specifications for high-grade absorbent papers suitable for use in the manufacture of laminated fiber sheet.

The Subcommittee on Mica Products is completing arrangements for the preparation of color transparencies of mica for visual grading. After careful study, agreement has been reached on the grades to be covered by the reference standards.

The Subcommittee on Conditioning reported that consideration is being given to a revision of the Tentative Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (D 618) to bring them into agreement with the recommendations of the Federal Specifications Board (see April Bulletin).

The Subcommittee on Electrical Tests recommended a revision of the Standard Methods of Test for Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies (D 149) which will incorporate the slow rate of rise test for dielectric strength. Action was also taken on revisions of the Standard Method of Test for Arc Resistance of Solid Electrical Insulating Materials (D 495). An extensive revision of the Standard Methods of Test for Insulation Resistance of Electrical Insulating Materials (D 257) is under way. Three separate drafts have been prepared and were discussed at an all-day meeting of the section responsible.

It was decided to hold the next meeting of Committee D-9 jointly with Committee D-20 on Plastics at the Holtel Biltmore in Dayton, Ohio, on February 24 and 25, 1948.

Plastics

Meetings of Committee D-20 and ten of its subcommittees were held on November 6 and 7.

The Subcommittee on Strength Properties reviewed the data obtained in cooperative tests on determining tensile strength of rods and tubes. These data will be studied and the tests continued, and it is hoped to have a test procedure ready for action at the next meeting. Work is to be under-

taken on methods to determine the tensile strength of films. There is considerable work under way on the flexure testing of thin samples. This project is expected to take at least another year to obtain the necessary data. Work is also to be undertaken on the development of a test for bursting strength of tubes.

A progress report was presented on the round-robin test program of studying the abrasion or scratch resistance of plastics using the Taber abraser. These studies include the visual effects of abrasion. A new section has been organized to study the mechanical effects. A definition of abrasion resistance is now in preparation.

The Subcommittee on Thermal Properties presented revisions in the Tentative Method of Test for Measuring Relative Mobility of Thermosetting Molding Powder (D 731), and in the Tentative Methods of Test for Deformation of Plastics Under Load (D 621). Both these revisions are subject to letter ballot vote of Committee D-20. This subcommittee reported the decision to undertake work on a study of post formality of laminates. This will be done in a new Section G under the chairmanship of Prof. R. K. Witt of Johns Hopkins.

The Subcommittee on Optical Properties reported plans to organize a new section on optical measurements using the gonophotometer for determining gloss and diffusion of supported and unsupported films. A new method of using the sphere hazemeter is about ready for submission to letter ballot of the subcommittee. In addition, the General Electric Spectrophotometer and the Hunter Null-method Haze-meter are being studied.

The Subcommittee on Permanence Properties presented a revision of the Tentative Method of Test for Colorfastness of Plastics to Light (D 620). The problem of exudation will be studied by a new section.

The Subcommittee on Specifications reported that specifications for plasticizers have been prepared but are awaiting completion of the necessary companion test procedures. These are being studied by the subcommittee on Analytical Methods. A method for determination of free phenol and free formaldehyde in phenol-formaldehyde resins is under consideration.

The Tentative Recommended Practice for Determining Mold Surface Temperatures of Commercial Molds was presented to Committee D-20 for letter ballot. Special attention is being given to the problem of working out a standardized mold for molding test specimens of thermoplastic materials. Also, a method for measuring shrinkage of molded plastics is being studied.

At the meeting of the Subcommittee on Impact there were two short papers presented with high-speed movies showing the action of test specimens in the impact test. There was a third discussion at this meeting on an investigation of the validity of the impact relationships of plastics. A list of research problems which should be suitable for investigation by college and university graduate students has been compiled and is now being studied. It is planned that this list appear in a future issue of the ASTM BULLETIN.

Shipping Container Committee Meets in Chicago

A TWO-day meeting, culminating with an inspection trip of the Quartermaster Food and Container Laboratories, held in Chicago, Ill., on October 30 and 31, proved of great interest and accomplishment to the members of Committee D-10 on Shipping Containers. Six subcommittees, along with the Advisory Committee, met on October 30 at the Bismark Hotel. The reports of these subcommittees were presented at the main meeting of the committee held during the morning of October 31, at the Quartermaster Food and Container Institute, Quartermaster Depot.

The subcommittee reports indicate a substantial list of standard definitions of terms pertaining to shipping containers and related items ready to be submitted for the approval of the committee and the Society. Two adaptations of the standard drop test (D 775) are being formulated for testing cylindrical containers and bags and sacks. Test methods covering the water resistance of containers (immersion method) and the water vapor permeability of reclosable shipping containers are in draft form. Studies are in progress looking toward the formulation of performance standards, testing procedures on interior packing materials, and on correlation of test data.

An interesting feature of the main meeting was a talk by Albert V. Grundy, Container Research and Development Division, Quartermaster Food and Container Institute, and a member of Committee D-10, on "Standards Required for Quartermaster Packing." Mr. Grundy pointed out that present common commercial practice is inadequate for domestic shipments as far as the Q.M.C. is concerned. The Institute is attempting to assist the user of shipping containers by stepping up the requirements after careful and impartial research has been made. Col. Chas. S. Lawrence, Commanding Officer of the Institute and a survivor of the Bataan Death March and Japanese prison camps, welcomed the committee members to the Institute.

Following adjournment of the meeting, a tour of the Food and Container Laboratories was conducted by Mr. Grundy and his staff. A special treat for committee members took place at the conclusion of the inspection when they were served a specially prepared luncheon followed by a presentation of certificates of membership in the "Guinea Pig Club." The qualification for membership in this unique organization is set up by the Institute on the basis of participation by certain invited groups in special luncheons prepared by the laboratories.

EDITOR'S NOTE: It is understood that the particular requirements for Committee D-10 members were survival for thirty minutes after partaking of a meal prepared principally from canned rations that were over three years old and had been shipped overseas and returned.

Committee D-13 on Textile Materials Has Much Work Under Way

A THREE-DAY meeting of the subcommittees of Committee D-13 on Textile Materials was held in Philadelphia, Pa., on October 15 to 17. As mentioned elsewhere in this issue, the committee cooperated with the Philadelphia District in sponsoring two technical sessions, one on flammability, the other on fibers. There were meetings of twenty subcommittees and sections over the three-day period.

A new Subcommittee on Hosiery was organized under the chairmanship of E. N. Ditton of the Gotham Hosiery Co., Inc. The National Association of Hosiery Manufacturers is cooperating in this work.

A new Subcommittee A14 on Bonded Fabrics was organized.

In cooperation with the National Bureau of Standards, a project is to be undertaken on problems involved in measuring wool content of individual blankets and the degree of uniformity from blanket to blanket obtained in production.

Work is being started on the development of methods of testing elastic fabrics. There was considerable interest expressed in work to be undertaken on quantitative methods of analysis including work on a proposed method of test for number of yarns from woven and knitted fabrics. A task group is being established to develop a method on this subject.

The Subcommittee on Household and Garment Fabrics reported that consideration is being given to a revision of the Tentative Specifications for Bleached Cotton Broadcloth (D 504) to eliminate differences between it and the Federal Specification for Broadcloth (CCC-B-686). Test requirements for shrinkage and colorfastness are also to be included in these revised specifications. A special task group has been appointed to investigate the field of upholstery fabrics and to determine whether there is need for standards for these materials. Consideration is being given to the development of methods for determining resilience and washability of blankets. A task group on work garment fabrics has been organized and includes representatives from various government agencies, consumer groups, and technical societies.

The Subcommittee on Felt has under consideration procedures for the chemical analysis of felt for determining protein fiber content; also procedures for determining compressional resiliency and compression set; mildew and fungi resistance.

At the meeting of Section II on Machines of Subcommittee B-1, Dean Hugh M. Brown of the Clemson Agricultural College, School of Textiles, reported on his studies on the effects of deeper fabric testing jaws. At this same meeting Dr. A. G. Scroggie presented a discussion on the pneumatic operation of cord test jaws.

At the meeting of the Subcommittee on Sampling, Presentation and Interpretation of Data, Dr. J. W. Hopkins of the National Research Council, Canada, presented a paper on "Precision of Laboratory Measurements of Breaking Strength of Textiles." At this same session a task group presented a comprehensive report containing recommendations for planning of interlaboratory tests.

At the meeting of the Subcommittee on Pile Floor Covering consideration was given to a new flame test. Other matters discussed were methods of testing single Kraft yarn, resistance to insect damage, intangible factors, and tests for determining fastness to various spottings, bleeding, etc.

The meeting of the Section on Wear Testing was well attended. The various cooperative test programs under way were reported and further work planned.

Adhesives Committee Reports on Many Projects

Prof. H. P. Meissner Gives Interesting Talk as Special Feature

Two distinct impressions gained from attendance at the latest meeting of Committee D-14 on Adhesives are, first, the multiplicity of problems in this relatively new field and, second, the thoroughness with which this committee is attempting to attack and evaluate each problem by scientific research on a coordinated basis. The keynote of the committee's activities is the free and ready exchange of data from round-robin tests and other coordinated research among committee members. This ensures a conclusive background of facts for the formulation of standards needed to control and measure the characteristics and properties of adhesives.

The committee held a very fruitful two-day meeting at the Hotel Cleveland, Cleveland, Ohio, on October 9 and 10. A good representation of the membership was in attendance at the series of eight subcommittee meetings followed by a luncheon meeting of the entire committee.

Touching on a few of the activities as reported by the subcommittee chairmen—considerable emphasis is being given to additional test methods on physical properties not as yet covered by existing standards. In the field of strength tests it is noted that further development of shear strength tests as pertaining to metal-to-metal and plastic-to-plastic are in process; a peel test method is in need of further refinement; a recommended practice on measuring fatigue is being prepared for letter ballot of the subcommittee; a cleavage test method is now ready for recommendation to the Society; work is being done on a simplified tensile strength test; and more round-robin tests are required preliminary to the formulation of a flexural strength test method. An impact strength test method has now been accepted by the Society (D 950).

The Subcommittee on Permanence, in studying the effect of biological factors, developed an interesting report on studies being made with mold, rot and roaches, preliminary to the preparation of a test method, in which many per-

plexing factors were discovered. The several projects under the Subcommittee on Working Qualities present numerous problems of procedure and interpretation; for example, the major problem in devising a means of measuring attack at present is that of finding suitable apparatus. One completed project was reported, namely, a consistency test which now has been prepared for letter ballot of the subcommittee.

The results of a letter vote show that a substantial majority of the committee are in favor of specifications based on performance with the privilege of specifying basic chemical type of material.

A second set of adhesives nomenclature was recommended for approval by the Society with discussion on a third set preliminary to approval by the Subcommittee on Nomenclature.

An interesting addition to the program of subcommittee meetings was a talk by Prof. H. P. Meissner of the Chemical Engineering Dept., M.I.T., whose subject was "Some Factors Affecting Adhesive Bond Formation." Professor Meissner presented his subject in a very clear and interesting fashion which promoted an equally interesting discussion. It was announced that the next meeting of Committee D-14 will be held in conjunction with the Spring Meeting of the Society in Washington, during the week of March 1, 1948.

News on Chemical Analysis of Metals

THOSE who follow the work of Committee E-3 on Chemical Analysis of Metals, and who are interested in the extensive work which this committee has completed are advised that the Tentative Methods of Chemical Analysis of Steel for Sulfur by Direct Combustion E 30–46 T) and the Tentative Methods of Chemical Analysis of Ferro-Alloys (E 31–46 T) were adopted as standard without revision on October 15, 1947. These methods adopted without change will not be republished, but will continue to appear in the 1946 Volume of Methods of Chemical Analysis of Metals. This is in line with the publication policy noted elsewhere in this BULLETIN under which any tentatives, whether specification or tests, adopted as standard in 1947 *without revision* will not be republished in the 1947 supplements.

A Proposed Tentative Photometric Method for Determination of Boron in Steel has been approved by Committee E-3 and will be submitted to the Administrative Committee on Standards early in 1948.

Thermal Insulating Materials Committee Meets at State College

THE FALL meeting of Committee C-16 on Thermal Insulating Materials was held at the Nittany Lion Inn, State College, Pa., on November 3, 4, and 5. In the pleasant environment of the Inn, which is adjacent to the campus of Penn State College, a succession of subcommittee meetings was held, concluding with a dinner meeting of the entire committee. A good attendance of membership and visitors reflected the continuing and growing interest in the activities of the committee.

Several recommendations pertaining to existing standards were acted upon, including a revision of the Test for Compression Strength of Preformed Block Type Thermal Insulation (C 165), and a revision of five definitions of terms included in C 168. Seven tentatives were recommended for advancement to standard, five being specifications on thermal insulating cements.

A number of projects are in advanced stages of study for formulation of test methods. These include methods of determining the density of block and pipe insulation, respectively, moisture adsorption, water absorption, thermal conductivity of loose fill insulation, fire resistance thermal conductivity of pipe insulation, fire resistance, and measurement of specific heat by the "Method of Mixtures" procedure.

New investigations were reported under way covering temperature resistance, corrosion resistance, and bacteria resistance. In the accumulation of data in setting up dimensional clearances and tolerances of pipe insulation, present studies will be limited to a temperature range of 32 to 600 F.

The committee will hold its next meeting during the 1948 Committee Week, March 1 to 5, in Washington, D. C.

Institute of Chemical Engineers, Meeting

THE American Institute of Chemical Engineers will hold its First 1948 Regional Meeting at the Roosevelt Hotel in New Orleans, La., February 15 to 19. E. A. Gastrock, Head, Engineering and Development Division at the U.S.D.A. Southern Regional Research Laboratory in New Orleans, is General Chairman for the Convention. Two symposiums are being planned on "High Temperature Refractories" and "Low Temperature Insulation" along with several general chemical engineering papers. W. E. Lobo, Director of the Chemical Engineering Dept., M. W. Kellogg Co., New York City, is arranging for the papers for the two symposiums. In connection with the meeting a number of plant visits are being arranged, and a very interesting Ladies' Program is being prepared.

New York Technical Council Meeting on Steel—Part of Lecture Series on Materials, Their Descriptions and Applications

THE Technical Societies Council of New York is arranging a series of lectures on Materials, Their Descriptions and Applications. The first one entitled "Steel" will be presented by Charles M. Parker, Metallurgical Engineer, American Iron and Steel Institute, New York City. His talk, concerning the steel industry in the United States and how steel is made and used, will be accompanied by a movie, in color, entitled "How Steel Is Made" (42 minutes). A discussion period will follow, with D. E. Boyd as Technical Chairman.

This meeting is scheduled for Tuesday evening, January 27, 1948, at 7:30, at the Engineering Societies Building (Room 501), 29 W. 39th Street, New York City. The New York Chapter of the American Society for Metals is sponsor. George O. Hiers, Metallurgist, National Lead Co. Research Laboratories, Brooklyn, is Chairman of the Meetings and Program Committee of the Council.

A.S.T.M. members and their friends are cordially invited to attend the meetings of this lecture series—later subjects to be announced.

Textiles for Peace and for War[1]

Dr. S. J. Kennedy, Office of the Quartermaster General

THE three broad classes of textiles with which I was concerned a good many years ago still seem to me to form a valid grouping of peacetime or civilian textiles as distinguished from military textiles.

PEACETIME

The *first type* may be illustrated by some of the products sold at that time in a limited way which were referred to as "sub-count bleached goods." They were heavily back-filled with a mixture of starch and talc to give them the appearance of a firm piece of fabric, and to conceal the fact that they were a low construction. I was led to believe that we could finish them better than our competitors, *i.e.*, the dust cloud could not be started as easily in handling our goods.

Having just come from college, I had developed certain ideas on the subject of ethics, and —I was rather concerned as to how the user might feel after such goods had been through the laundry. I could not help wonder why someone did not insist that the true value of these goods be revealed to them.

Now, let me remind you that every day in this year of 1947 textile items that are not actually what they appear to be are still being sold to consumers. For that is the characteristic of this first type of textile.

If the consumer is not provided with some means for learning these facts, and assumes a quality of performance that is not there, the customer has definitely been misled or been allowed to mislead himself. Consumers would like to know, just in case certain advertised Elysian properties are not there, or in case they are unwilling to pay an excessive price for them, whether they can compare the price and quality of two types of sheets and decide for themselves in a good old democratic way whether the higher priced one is worth the money. Fortunately, there has been an increased amount of standardization of products, despite reluctance in some circles. Such comparisons should be more possible in the buyers' market which is coming. We will hope that through stronger consumer demand for facts, and greater product identification on the part of progressive textile producers, the class of textiles which appear to be different than they actually are, will in the future find a smaller and smaller market.

The *second* of these three classes of textiles is comprised of products which possess nonintrinsic or psychological values. There are such values, and those of us who pay our wives' bills are acutely conscious of them. Let us hope that next year, the "New Look" will not be as expensive, or make such extravagant demands upon the output of the textile mills of the world that must meet the deficit created by the wholesale destruction of war.

The *third* class of textiles, which to the Army as a consumer, is a prototype in civilian goods of military textiles, is this class of *industrial textiles*. While the term "industrial textiles" is often applied to all nonapparel and nonhousehold products, here let us consider it in the more limited sense of textiles purchased by industrial concerns to meet specific requirements of some particular end use. I should like to be able to refer to such textiles as *engineered* textiles, and perhaps in a few years that term will be truly appropriate.

When I first came into the textile industry, they were sold on a different basis from other fabrics. They were used generally as components of some nontextile product, or used in some industrial process. They were expected to possess certain physical properties, in most cases of strength or wear characteristics. They were studied and improved.

This field of industrial textiles has greatly expanded in recent years, both as to range of products, and the degree of fabric engineering that has come to be applied to the study of real requirements.

The dominant characteristic of this class from one viewpoint is that the consumer determines required performance characteristics for the use, and purchases a textile material designed specifically to meet them. Frequently the seller may do a large part of the work of finding out what the required characteristics are. In many cases the particular requirements may be quite simple—just a single property perhaps. In other cases the consumer may give exhaustive study to the performance requirements and present a complex set of standards that must be met.

WAR MATERIALS

What the industry must produce in time of war, for the agency delegated to do the fighting and win, must be of much different quality than for peace. For most of the textiles the Army buys in time of war are in categories where performance standards are practically nonexistent in time of peace.

The old "Saw" that the things the Army needs are good civilian products or that the Army should follow good commercial practice in the purchase of its textiles and clothing is a dangerous policy.

Civilians can be persuaded, either by nonperformance of industry or by outright advertising, that they should be content with much less in the way of performance standards than the Quartermaster can find out by test and research are actually needed for such uses. Furthermore both they and the industry can even be persuaded that something that is needed cannot be done, *e.g.*, shrinkproofing of wool, which could have been solved years ago, but which the Army had to accomplish in time of war.

Good commercial civilian practice doesn't go far in determining how to clothe a man for weather at −40 F. for several weeks. Good commercial practice is to stay far away from such places, or if one has to go there to find a heated building, a warm fireplace, and something to warm up the interior, after a bout of a few hours with such weather. With so few people interested it is unlikely many commercial manufacturers will be interested in solving this problem to develop a profitable market.

Where there are direct parallels of civilian products it is particularly difficult sometimes to persuade some people that military textiles should be better than civilian goods. If you or your son were somewhere out in a foxhole, you would not want to be clothed in some people's ideas of good commercial practice.

SPECIFICATIONS MUST REFLECT PERFORMANCE

What is the most important point I

[1] Abstract of an address presented at the Dinner Meeting in Philadelphia on October 16, sponsored by the Philadelphia District Council and Committee D-13 on Textile Materials.

can lay before the members of Committee D-13? It is this, that our specifications are intended to reflect desired performance in active use, not acceptance by inspectors. You will say, how obvious! And yet many of us are inclined to think about possible rejections based on the legal words of a specification, rather than the intent of those people who are trying to put into words what they visualized the material must do in some military job.

Roscoe Pound, in his stimulating book of a generation ago, "The Spirit of The Common Law," when speaking of judicial reform made the statement:

> "It is timely to examine the body of tradition on which the law relies, to ascertain the elements of which it is made up, to learn its spirit, and to perceive how it has come to be what it is, to the end that we may know how far we may make use of it in the stage of development upon which the world has now entered."

With a word or two changed, that statement represents exactly the view I would impress upon you with respect to our joint industry-government efforts to make better textiles for national defense. Specifications and government requirements must not simply be "something to meet." Somehow we must "get across" something of the background from which the specification is derived, the determination which led to the adoption of its various elements, to pass along something of the spirit of the endeavor being made by a great many people to solve problems of great magnitude and great significance to national defense.

Without something of that spirit, we shall get lost all too soon in the details of test methods. Detailed spade work is essential. Many times we are told, "It is not what you want but what you can get, at least get economically, that must be taken into account in setting our quality levels." Nonetheless, we must keep trying to get something better than we have had, and only give up after we have exhausted every possibility.

Our endeavor in the Quartermaster Corps is like that of medical research, the saving of human lives, as well as the winning of battles. Those in ordnance who make poison gases seek for the most efficient ways to destroy the enemy's life. We, whose job it is to feed and clothe, carry the greater burden of saving life and preserving efficiency. We must fight two enemies—and the greatest is a hostile environment. Try and live in such environment without any of the conveniences of modern civilization. Take what you would be willing to carry on your back and march 20 miles a day, or which you would want when you tried to win a 100-yard dash, with disaster if you lose. Try it up in Minnesota this winter —or in Maine, somewhere within that area, which our 1920 National Defense Policy envisioned we would protect, and take with you the clothing we developed during the last war, not that with which we started the war. The latter, General Doriot liked to say, was reasonably adequate for fighting in Maine in the summer and Florida in the winter.

After you have tried that and have considered our present situation, I believe you will be impatient, as I am, with the obstacles in the way of more rapid improvement of Army textiles and textile items.

Arctic Problems

According to Dr. Hoyt Lemons, Research Director for Environmental Protection, man is our weakest link in any plans for military operations under Arctic conditions. We must use his energy efficiency and know his basic limitations. For man in the Arctic must provide his own heat from the functioning of his physiological processes. Food and bodily activity must generate and maintain heat. We can conserve the heat by his clothing, and tentage or shelter. Thus, food, clothing and shelter and the man himself comprise one basic problem, and are so closely interrelated as to be inseparable.

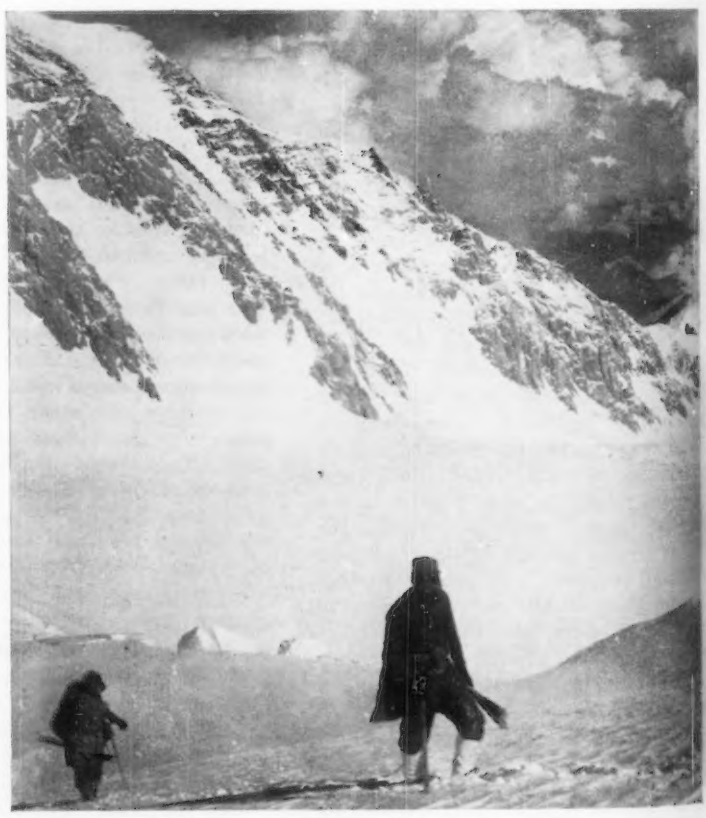
Thus better clothing alone will not solve the Arctic problem. Men cannot be inactive for too long a time. Casualties of any kind present an extremely serious problem.

We have not gone nearly as far as it is theoretically possible in making our clothing truly efficient. A great reduction in weight can be made, and we are now testing clothing which will reduce the over-all weight of the Arctic assembly by at least a third.

The efficiency of men in the Arctic is much lower than in any other environment. In part this is the result of the tremendous temperature differential between his body temperature and the air, and in part it is the result of the heavy and cumbersome clothing necessary to insulate the body. Increased efficiency will come with lighter clothing. In a large part, too, his efficiency is related to his psychological adjustment to the Arctic. Living in a bleak, barren wilderness of snow and ice where everything, especially nature herself, is conspiring to destroy, will always require a profound psychological adjustment for men who have lived in a normal climate.

A.S.T.M. Work

What can A.S.T.M. Committee D-13 on Textiles do to further the cause of national defense? I must state emphatically that the work of Committee



In the Arctic

D-13 is of profound value to the development of military textiles. All of our textiles are *industrial textiles*, as I have used the term, or as I should like to be able to say, *engineered* textiles. To make the better specifications needed for textile clothing and footwear, we must have ways to tell the industry what we need, with a precision which will insure our getting that. We need ways to test, in some cases better than we have at present and for others wholly new tests which have not yet even been developed. Committee D-13 can make a great contribution by continuing and expediting the improvement of test methods in present and new fields.

Sacred Specifications?

Some speak of Government specifications as though the Almighty had spoken and no questions should be raised. Our specifications are attempts to tell you at a given time what we think we need. As research and development progresses, our ideas of what we need are certainly going to change, and as they do, our specifications will have to reflect these changes.

A specification at any one time is only a way-station along an endless highway. We stop off there to fill our supply tank and as soon as we can we move on. Our next stopping point, if we have made real progress, should call for something better. There is nothing sacred about a specification. We are continually looking for ways to improve them and we would like to have suggestions from you, who understand their application perhaps even better than we do, as to how we could change the specifications in any respect or the test methods or our products in any way that would enable us to get what we really need.

In the Army we must initiate research and development, which in many fields goes much beyond what civilian consumers would attempt to do to develop textiles for these uses. Thus, in a sense research to develop textiles for national defense, is pioneering where civilians later also will reap a benefit. We feel that our work is justified in part by the savings which result to the public as a whole from the development of longer wearing textiles and the corresponding reduction in military needs. There should be other benefits to consumers from the better textiles produced from our research. Whether for war or peace, the textile test methods and accompanying instrumentation will continue to provide the stepping stones to further advances, and in their development, I am sure A.S.T.M. Committee D-13 will continue to play a leading part.

Modification of Textile Fiber Properties Through Finishing Operations[1]

D. H. Powers, Monsanto Chemical Co.

In the past we expected the properties of our fabrics to be determined by their fiber content. Fabrics to give warmth were made of wool; fabrics for hard wear were made of cotton; fabrics to be cool were made of linen; and fabrics for style, luster, and luxury were made of silk. Today—in part, at least, as a result of our studies of clothing for the Army and Navy in the past war—we know that wool is not necessary for warmth, or linen for coolness. We know that fabric properties are frequently independent on fiber content. We have learned that a fabric imparts warmth because it is thick and is cool because it is thin, without any consideration of its fiber content. Incidentally, a fabric feels warm when it is rough and feels cool when it is smooth. If we give our worsteds a smooth finish, they feel cooler than a napped or rough cotton.

While a certain number of fabrics made from *blends* of fibers have been successful, a great many have been a great disappointment. Mixing two different fibers does not often yield a fabric of composite properties. Rayon-wool blends have been frequently disappointing because the resulting fabrics do not possess the advantages of the two fibers but rather the disadvantages of each, and fabric instability results from lack of balance between the two fibers. Wool-nylon blends showed the greatest promise when they contained 75 per cent of nylon or more.

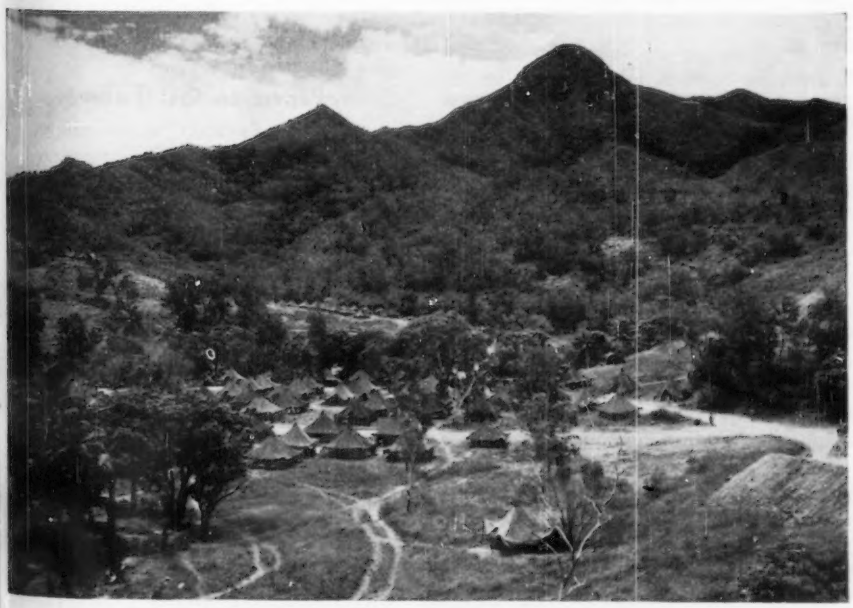
A great many of the problems which arose in the development of blends were an outgrowth of our earlier thinking that fibers make the fabric. Actually, recent work has repeatedly shown that a more important slogan is, "The finish makes the fabric." Certainly in a great many of the cases examined a *planned finish* would have contributed more new qualities to the fabric than fiber blending. Better shrinkage control can be imparted to rayon in the finishing than in blending. Greater resilience can be given to cottons and rayons in finishing than in blending. Wool will stand up to washing far better with proper finishing than with all types of fibers blended with it.

Pursuing the suggestion that the "finish makes the fabric," a number of important developments can be traced.

I. The Army's Tentage—During the war it was necessary that our tentage be tough, durable, fireproof, waterproof, and mildewproof. No blend of fibers would produce this result, but proper *finishing* of heavy cottons gave all of these properties and opened for cotton the largest market in its history.

II. Washable Rayons—Recent research has shown that rayon slowly dissolves in warm alkali, and this alkaline attack of the fiber itself causes the greatest damage in repeated washings. The solution of this problem is not in diluting the rayon with other fibers of more or less

[1] Condensed version of a paper presented in a session in Philadelphia on October 16, sponsored by the Philadelphia District and Committee D-13.



In the Tropics

alkali stability, but rather in finishing the rayon with a chemical or resin which protects it from the attack of the alkali.

III. Shrinkage—Shrinkage has been a problem in all fabrics, whether cotton, rayon, linen, or wool; and blends rarely help the problem and frequently aggravate it. By mechanical, chemical, and resin *finishing* it has been possible to solve shrinkage problems for all of the fibers and even blends. In this case especially we find that fabric stability is an essential quality for shrinkage control and can only be achieved in the finishing. Fiber blends usually make the problem far worse.

IV. Rainwear—No fiber or blend of fibers has proved entirely satisfactory for Army rainwear, since the pickup of water and the added weight of water carried by a soldier in a heavy rain was extremely objectionable. A durable water-repellent finish applied to a tightly woven cotton has given the most satisfactory performance. Certainly in the field of rainwear all fabrics should receive a durable water-repellent finish, as the public expects and wants a garment which will shed water during its entire useful life. No matter what fiber or blend is used, a repellent finish must be used in this field.

V. Muss Resistance and Wrinkle Recovery—A great many blends have been produced in an effort to obtain fabrics with adequate wrinkle or muss resistance. It is surprising how little wool (in low concentrations) improves the resilience of rayon and how much rayon hurts the resilience of wool. Certainly it is recognized both in this country and particularly in England and on the Continent that resin finishing is the only satisfactory method of imparting true resilience to rayons and more recently to cottons. In the finishing of fabrics for muss resistance, they are frequently built up as much as twenty per cent in weight, and best results will only be obtained if the fabric is woven lighter with the type of finishing planned for. All too frequently we apply a resin for crease resistance as an after-thought to a woven or blended fabric with inadequate qualities.

VI. Wear Resistance—The evaluation of wear resistance is held up by the lack of adequate test methods. While the abrasion test meters frequently give reproducible results, they do not necessarily give any true measure of service and field performance, since stiffness, smoothness, resilience, and elasticity all play an important part, which the abrasion meters do not necessarily measure. In any event, resin finishes of the dispersed or latex type frequently give abrasion resistance improvement of three to five fold. It may be that correlation between test methods and field performance will be worked out and that some of these abrasion resistors will find a market on work clothes. Here again, the finish plays an important and sometimes a dominant role in the production of fabrics with greater wear resistance.

VII. Fire Resistance—In the development of fireproof and fire-resistant fabrics, the finish is all important, since none of the usual fibers is fireproof. Wool, of course, has a slow burning rate, but the work on fireproof finishes of a durable or permanent type will allow any fiber, which will respond, to find markets in this field. While a great deal more work needs to be done to improve and perfect the new fireproof finishes, they already greatly reduce the flammability of existing fabrics.

VIII. Nonwoven Fabrics—While nonwoven fabrics are still in the development stage, there is no question here but that the "finish makes the fabric." Certainly the card webs before resin or chemical treating have no value as fabrics, and the toughness and uniformity of the finish establish the value of these nonwovens. It has been recently pointed out that nonwovens promise to be one of the most important developments in the textile field. It will be the finish that puts over this development when that day arrives.

In addition to the specific cases cited above, there are numerous other fabrics such as durable glazes, crisp curtain or organdie fabrics, and shrink-resistant socks where the finish is quite obviously the most important step in the fabric development.

It is suggested that all too frequently in the past we have tried to produce new fabrics and effects by blending fibers when the problem could be more easily and efficiently solved by developing new finishes. We have tended to use our finishes as an after-thought and not as an important part of our fabric building and new fabric development program. When a finish can build up a fabric 25 per cent, when it can become tied onto the fibers and become a permanent part of the yarns, when it can give shrinkage control and wrinkle resistance, when it can impart wear resistance, fireproofness, mildewproofness, and waterproofness, when it can open entirely new and unique markets for old fabrics, then it seems evident that we could seriously consider that, in the light of current developments, it is the FINISH THAT MAKES THE FABRIC.

An abstract of the interesting paper by Mr. Bouvet on Textile Fibers, and the three papers comprising the Symposium on Flammability held on October 16, will be included in the January BULLETIN.

An Introduction to Metallurgy

THE second edition of this book, by Joseph Newton, Professor of Metallurgy, University of Idaho, presents an introduction to the field of metallurgy as a whole and provides a foundation for advanced and special studies in metallurgical subjects. An attempt has been made to emphasize principles rather than practice and to use generalized discussions as far as practicable. Examples of some typical calculations are included in the text, and a list of exercises is appended to each chapter. A short reading list appears at the end of each chapter, and these lists include some references to articles in recent periodicals. Important features of this second edition include: an expanded discussion of pyrometallurgy; new material on corrosion; more alloy diagrams; and the addition of a section on powder metallurgy. Simplified production figures now emphasize world production.

Copies of this book, which includes a quite detailed subject index, can be obtained from the publishers, John Wiley & Sons, Inc., New York City, at $5.50. The book aggregates some 650 pages.

Papers on Gas Turbines

SEVERAL interesting technical papers on gas turbines presented at meetings of The American Society of Mechanical Engineers, including the 1947 semi-annual meeting, are published in the August *A.S.M.E. Transactions*. Papers and their authors are as follows:

Design and Operation of Some Experimental High-Temperature Gas-Turbine Units, by A. D. Hughes

Metallurgical Considerations of Gas Turbines, by N. L. Mochel

Haynes Alloys for High-Temperature Service, by W. O. Sweeny

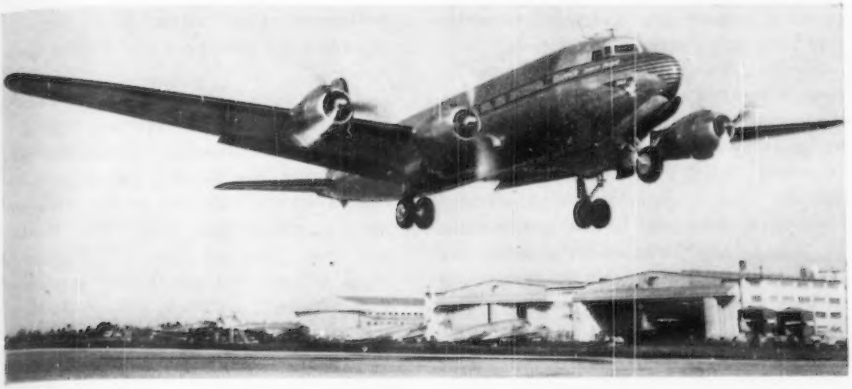
Precipitation-Hardened Alloys for Gas-Turbine Service, by Howard Scott and R. B. Gordon

I—Metallurgical Considerations

II—Design and Application Data

Materials for Power Gas Turbines, by C. T. Evans, Jr.

Nickel-Chromium Alloys for Gas-Turbine Service, C. A. Crawford



Pan American Uses A.S.T.M. Standards

J. T. HENDREN, the representative of the A.S.T.M. membership held by Pan American World Airways since 1932 was recently feted on completion of the 20,000th fuel test conducted under his direction. The accompanying photograph shows Mr. Hendren beginning this particular test at his Miami laboratory. Gasoline from Bangkok, Thailand (Siam) was the material being tested. Established 17 years ago, the Pan American laboratory still has as its main function the analysis of aviation fuels and the study of their behavior and care. It is pointed out that in some parts of the terrain in which airports are established, only once a year is it possible to transport a sufficient volume of gasoline. A statement from the company indicates that gasoline is by far the largest single expense in the company's budget, next to its payroll. The Latin American Division alone spends some $600,000 monthly for fuel, which is supplied by various refiners.

Mr. Hendren makes extensive use of A.S.T.M. specifications and test methods, not only for petroleum products, but for other materials such as soaps and the like. Methods used daily are the following:

D 526—Tetraethyl Lead in Gasoline
D 323—Vapor Pressure of Petroleum Products (Reid Method)
D 86—Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products
D 90—Sulfur in Petroleum Oils by Lamp Method
D 130—Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline
D 873—Oxidation Stability of Aviation Gasoline
D 481—Acid Heat of Gasoline
D 614—Knock Characteristics of Aviation Fuels
D 93—Flash Point by Means of the Pensky-Martens Closed Tester
D 97—Cloud and Pour Points
D 189—Carbon Residue of Petroleum Products
D 482—Ash Content of Petroleum Oils
D 99—Viscosity by Means of the Saybolt Viscosimeter

J. T. Hendren

Engineers' Requirements

THE profession of engineering requires that an engineer be more than a skilled mechanic or craftsman. In his undergraduate training and in his postgraduate reading and study, he should recognize the importance of the fields of economics and government, of logic and psychology, of sociology and human relations. Knowledge of the safe and economic use of materials and machines is no longer enough. The professional engineer must have also an understanding of men, money, markets, and social developments.

It is not only the engineer's duty to take a leading part in government and public affairs but he must inform the public of his availability and his qualifications for such leadership. Speaking and writing ability should be cultivated and used to achieve this end.

If the broadly trained engineer leader will apply the scientific method to the utilization and assimilation of engineering developments, with the integrity fitting his profession, society will welcome his leadership.—Edward R. Stapley, Acting Dean of Engineering; from *Oklahoma State Engineer*.

To the A.S.T.M. Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in A.S.T.M. and include a membership application blank

{Signed}_____

Address_____

Date_____

Flameproofing Textile Fabrics

ALL who have had occasion to delve into the extensive but scattered and desultory literature on flameproofing of textiles will indeed welcome the ACS Monograph on "Flameproofing Textile Fabrics," written by a staff of experts under the editorship of Robert W. Little. It is the most comprehensive work yet published in a field which has been in need of such a systematic review and fundamental approach. The results of about three years of research carried out at Columbia University under a National Research Council program are covered, as well as much additional information obtained from other programs executed by the Quartermaster Corps and various Service laboratories. Although the investigations were undertaken in search of solutions for the immediate problems of the Armed Services, the findings are also applicable to civilian problems and constitute a decided advance of knowledge in the general field of fire retardants. The book is an excellent analysis of the present status of textile flameproofing, though the authors are at pains to point out the need for further research before ideal fire retardants are achieved.

The material is arranged in three sections titled, respectively, "Fundamentals," "Methods," and "Applications." In Section One on "Fundamentals" the objectives of flameproofing treatments are defined, and a discussion of the nature of cellulose and its normal degradation reactions is given as background for consideration of the effects of fire retardant materials on the course of thermal degradation. Pyrolysis and combustion studies provide the basis for a much clearer understanding of afterflaming and afterglow prevention and for the development of theories of flameproofing and glow-proofing mechanisms which have heretofore been only partially suggested.

Section Two on "Methods" covers test procedures suitable for the thorough evaluation of a fire retardant treatment, and also the general types of flameproofing processes available for treatment of cotton fabrics. For each type of treatment there is a discussion of the mechanisms by which the included retardants are believed to function and a description of commercial application practices and equipment.

Section Three on "Applications" presents the methods employed by the Armed Services in developing and evaluating flameproofed fabrics for particular military clothing and equipage purposes. Much of this information will prove applicable to the somewhat different requirements of civilian usage.

The book contains 410 pages. It is well written, includes many supporting experimental data, and the task of combining the contributions of a large group of authors in a well-organized, continuous whole has been admirably executed.

The book is published by the Reinhold Publishing Corporation, 330 West 42nd St., New York, N. Y., and the price is $6.75 a copy.

MARJORIE W. SANDHOLZER

Directory of Commercial and College Laboratories

A COMPLETE listing of commercial and university testing and research laboratories throughout the country, together with indications of the type of commodities tested, has been compiled by the National Bureau of Standards. This pamphlet is now available from the Government Printing Office as NBS Miscellaneous Publication M187 entitled *Directory of Commercial and College Laboratories.*

As the principal agency of the Federal Government for research and testing in physics, mathematics, chemistry, and engineering, the Bureau makes tests and carries out investigations for other Government organizations. However, it does not make tests for private individuals if other laboratories can do the work with the required accuracy. Since inquiries regarding such service are often received, this classified list was assembled to inform interested persons of the location of other testing facilities. It is expected that the directory will also be of value to the large number of purchasers who are not equipped to make their own acceptance tests and have therefore hesitated to buy on specifications.

Information is given concerning 220 commercial laboratories, with 80 branches o offices, and 189 college laboratories used for research and testing as well as instruction. *Miscellaneous Publication M187 may be obtained only from the Superintendent of Documents, Washington 25, D. C., at 30 cents per copy.*

Publication on Printed Circuit Techniques

IN RESPONSE to an unprecedented demand for technical information on printing electronic circuits the National Bureau of Standards has just published the first comprehensive treatment of this subject entitled *Printed Circuit Techniques,* by Drs. Cledo Brunetti and R. W. Curtis. The booklet consists of 10 chapters totaling 43 pages and is adequately illustrated. NBS Circular 468, *Printed Circuit Techniques,* is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., at 25 cents per copy.

To the A.S.T.M. Committee on Membership, 1916 Race St. Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below.

_____

_____

This company (or individual) is interested in the following subjects: *{indicate field of activity, that is, petroleum, steel, non-ferrous, etc., etc.}*

_____

*{Signed}*_____

Date_____ Address_____

New Members to November 21, 1947

The following 54 members were elected from October 1 to November 21, 1947, making the total membership 6403.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

CHICAGO RAILWAY EQUIPMENT CO., Frank W. Lewis, Mechanical Engineer, 1928 W. Forty-sixth St., Chicago 9, Ill.

FEDERAL MALLEABLE CO., C. L. Liebau, Executive Vice-President, 805 S. Seventy-second St., Milwaukee 14, Wis.

STRUCTURAL CLAY PRODUCTS INST., REGION 5, James R. McAdams, Regional Engineer, 228 N. LaSalle St., Room 1501, Chicago 1, Ill.

Cleveland District

CLEVELAND GRAPHITE BRONZE CO., THE, E. J. Gilmore, Assistant to Chief Engineer, 17000 St. Clair Ave., Cleveland 10, Ohio.

BOOTY, RAYMOND G., Assistant to the President, Interlake Chemical Corp., 1900 Union Commerce Bldg., Cleveland 14, Ohio.

HOFFMAN, GEORGE, Technical Director, The Elco Lubricant Corp., Jennings Rd. and Denison Ave., Cleveland 9, Ohio.

NELSON, J. M., Chairman, Blast Furnaces, Coke Ovens and Open Hearth Committees, American Steel and Wire Co., Rockefeller Bldg., Cleveland 13, Ohio.

VANDAVEER, F. E., Chief Chemist, The East Ohio Gas Co., Foot of E. Sixty-third St., Cleveland 14, Ohio.

Detroit District

FORSTER, WERNERT & TAYLOR, H. J. Wernert, Partner, 733 Nicholas Bldg., Toledo 4, Ohio.

MAUMEE MALLEABLE CASTINGS CO., THE, E. H. Doering, Secretary and General Manager, Woodville St. and W. & L. E. Ry., Toledo 5, Ohio.

FARLEY, NELSON E., JR., Chief Experimental Chassis Engineer, Kaiser-Frazer Corp., Willow Run, Mich. For mail: 1143 E. Forest, Ypsilanti, Mich.

MARCE, ROGER E., Director of Laboratory, Neilson Chemical Co., 6564 Benson, Detroit 7, Mich.

New England District

FEUER, LEO J., Development Engineer, William Carter Co., Needham Heights, Mass. [J]*

RICHARDS, DONALD G., Chief Mechanical Metallurgist, Hamilton Standard Propeller, Division United Aircraft Corp., E. Hartford, Conn. For mail: R.F.D. 2, Andover, Conn.

New York District

ROCKWELL MANUFACTURING CO., P. J. Rochford, Engineer, 4207 First Ave., Brooklyn 32, N. Y.

WORLD STEEL PRODUCTS CORP., J. B. Sussman, President, 448 Tiffany St., New York 59, N. Y.

CALAWAY, K. G., Engineer, Sun Flame Appliances, Ltd., 595 Broad Ave., Ridgefield, N. J.

GRUENWALD, ERNST, Manager, Incor and Technical Service, Lone Star Cement Corp., 342 Madison Ave., New York 17, N. Y.

SCHWARZ, DAVID R., Chemical Engineer, Schwarz Laboratories, Inc., 202 E. Forty-fourth St., New York 17, N. Y.

SPRUNG, LIONEL, Manager of Building Material Div., Industrial Sales Corp., 500 Fifth Ave., New York 18, N. Y.

THOMMEN, LOUIS A., Division Engineer, Shell Oil Co., Inc., 3706 Eighty-second St., Jackson Heights, N. Y.

THYRRE, S. G., Vice-President, National Portland Cement Co., 11 W. Forty-second St., New York 18, N. Y.

Philadelphia District

ORR & SEMBOWER, INC., CHEMICAL DEVELOPMENT DIVISION, J. E. Simpson, Director, Box 358, Reading, Pa.

HYLTON, W. HAROLD, In Charge of Research and Testing Lab., Berkshire Knitting Mills, Reading, Pa. For mail: 820 Franklin St., Wyomissing, Pa.

LAUBER, EDMUND L., Executive Vice-President, NoMend Hosiery, Inc., 133 W. Berkley St., Philadelphia 44, Pa.

PHELPS, NEIL T., Superintendent, Sinclair Refining Co., Paint Dept., Box 516, Marcus Hook, Pa.

Pittsburgh District

BROOKS, WILLIAM BARKER, Metallurgist, Park Bldg., Pittsburgh, Pa.

LANKFORD, W. T., Research Associate, Carnegie-Illinois Steel Corp., Research and Development Div., Pittsburgh, Pa.

Southern California District

MOZLEY, PAUL P., Engineer, Materials and Processes Group, Lockheed Aircraft Corp., Burbank, Calif.

UNIVERSITY OF SOUTHERN CALIFORNIA, THE, COLLEGE OF AERONAUTICS LIBRARY, Santa Maria, Calif.

Western New York and Ontario District

EASTMAN KODAK CO., Miss Elsie Garvin, Librarian, Kodak Park Works, Research Labs., Bldg. 59, Rochester 4, N. Y. [S]**

KLINGER, AUGUST E., President and Treasurer, Buffalo Steel Co., Tonawanda, N. Y.

TRUESDELL, WILLIAM S., Sales Manager, Buffalo Steel Co., Tonawanda, N. Y.

U. S. and Possessions

AMERICAN COKE AND COAL CHEMICALS INST., L. A. Schlueter, 729 Fifteenth St., N. W., Washington 5, D. C.

DALTON FOUNDRIES, INC., THE, C. H. Ker, Vice-President, Lincoln and Jefferson Sts., Warsaw, Ind.

DOMINION FOILS (CANADA,) LTD., B. J. Kruger, Executive Vice-President, Cap de la Madeleine, P. Q., Canada.

MUNCIE MALLEABLE FOUNDRY CO., J. G. Malnoski, President, Muncie, Ind.

NEWNAN COTTON MILLS, Wyllys H. Taylor, President, Newnan, Ga.

PARAMOUNT DIE CASTING CO., F. A. Reddel, General Manager, 607 Ann St., St. Joseph, Mich.

BACHINGER, PETER T., Graduate Student, School of Textiles, North Carolina State College, Raleigh, N. C. For mail: State College Station, Box 3121, Raleigh, N. C. [J]

CORNELL, HOLLY A., Partner, Cornell, Howland, Hayes & Merryfield, 212 Rennie Bldg., Corvallis, Ore.

GULLEDGE, PAUL J., Chief Testing Engineer, Opelika Textile Mills, Inc., Opelika, Ala.

HOLMES, MARK N., Laboratory Director, May McEwen Kaiser Co., Burlington, N. C.

LARRICK, LEWIS, Textile Physicist, Office of Naval Research, Washington, D. C. for mail: 113 Washington St., Cnarlottesville, Va.

LEES, HENRY M., Concrete Technician, Seattle Department of Lighting, Third and Spring, Seattle 4, Wash. For mail: Ross Dam, Rockport, Wash.

MCABEE, ELSIE, Testing Supervisor, Casein Company of America, Division of The Borden Co., Bainbridge, N. Y.

MOFFAT, G. BRUCE, 2168 Sherbrooke St., W., Apt. 8, Montreal, P. Q., Canada. [J]

SHARP, W. W., JR., Vice-President, Chadbourn Hosiery Mills, Inc., 2417 N. Davidson St., Charlotte, N. C. For mail: Box 1891 Charlotte, N. C.

Other than U. S. Possessions

KEURINGSDIENST P. T. T., POSTAL AND TELECOMMUNICATION SERVICE OF THE NETHERLANDS, Binckhorstlaan 36, The Hague, The Netherlands.

BRUDAL, HOLGER, Chief of Laboratory, Vegdirektoratet, Veglaboratoriet, Schwensensgt. 6 Oslo, Norway.

KHAN, M. A., Indian Highway Delegate and Assistant Engineer, Public Works Dept., Patna, Bihar, India. For mail: River View Cottage, P. O. Gulzarbagh, Patna, Bihar, India.

NIELSEN, H. K. RAASCHOU, Director of Research, Central Research Laboratory, Danish Varnish and Paint Industry, Oster Voldgade 10 L, Copenhagen K, Denmark.

RAMAMURTI, T. V., Technical Director, National Radio and Engineering Co., Ltd., 26 Sleater Rd., Grant Rd., Bombay 7, India.

ROSENTHAL C, JORGE F., Apartado 2181, Lima, Peru. [J]

*[J] denotes Junior Members.
**[S] denotes Sustaining Member.

Personals . . .

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

JOHN L. McCLOUD, Head, Department of Chemical Engineering, Ford Motor Co., has been nominated for 1948 Vice-President of the Society of Automotive Engineers, representing the newly authorized Engineering Materials Activity. Mr. McCloud has been representative of the Ford Co. A.S.T.M. membership since 1924 and has been active throughout the years on many A.S.T.M. technical committees.

L. C. FLICKINGER has been appointed Chief Chemist of the Youngstown district of The Youngstown Sheet & Tube Co., succeeding the late D. A. Russell. Mr. Flickinger has been with Youngstown Sheet & Tube for thirty years as chemist and research chemist, and for the past twelve years as assistant chief chemist.

A. LLOYD TAYLOR, formerly Vice-President in Charge of Research and Development for H. L. Shaw and Sons, Portsmouth, N. H., and Boston, Mass., recently accepted a position as Research Supervisor in the Wyandotte Chemical Corp. Research Laboratories, Wyandotte, Mich., where he will work on industrial detergents. Dr. Taylor has had many years' experience in this field both as Director of Research for Oakite Products Co., and as Director of the Department of Chemistry, Pease Laboratories, New York.

On the merger of the Budd Wheel Co., The Edward G. Budd Manufacturing Co., and the Budd Induction Heating Co. into The Budd Co., C. L. EKSERGIAN, former chief engineer of the Budd Wheel Co., has been made Executive Engineer and Assistant to the Vice-President in Charge of Engineering in the new organization.

E. C. SMITH, Chief Metallurgist, Republic Steel Corp., Cleveland, Ohio, and recipient of the A.S.M. Gold Medal for 1946, has been awarded a degree of doctor of science by Case Institute of Technology.

TOM BARLOW, previously with the Vanadium Corp. of America and Battelle Memorial Institute, has joined the Eastern Clay Products, Inc., Jackson, Ohio, as General Sales Manager.

A. B. GIBSON, Founder and President of the Gibson Electric Co., Pittsburgh, Pa., was awarded the honorary degree of doctor of engineering by the Clarkson College of Technology, Potsdam, N. Y.

JOSEPH J. MAYER has been elected Vice-President and Director, Lumen Bearing Co., Buffalo, to succeed the late C. H. Bierbaum. He will continue to serve as General Superintendent, as for the last ten years, and will also direct the technical and engineering work.

J. PORTER LANGFITT has been made Vice-President in Charge of Refining, Pure Oil Co., Chicago. Mr. Langfitt joined Pure Oil in 1925 at the refinery which the company then operated at Marcus Hook, Pa., his first job being as a laborer. He rose rapidly in the organization, serving successively as construction engineer, stillman, district engineer in the distillation and process departments, and since 1937 until his recent promotion assistant to the vice-president for refining.

THE MINNESOTA AND ONTARIO PAPER CO. recently completed its new research laboratory at International Falls. With the new laboratory equipped for the analysis, testing and development of present products and new products, and with a carefully planned and directed research program, it is expected that new uses for present products and chemical by-products will be found.

ROY A. SHIPLEY, President of the National Fireproofing Corp., Pittsburgh, was reelected President of the Structural Clay Products Institute. JOSEPH A. BROWN, President, Baltimore Brick Co., and W. GARDNER LONG, of the New England Brick Co., Boston, were among the other officers reelected. RAND RODGERS, Vice-President, Alton Brick Co., St. Louis, is a newly elected member of the Association's Board of Directors.

MALCOLM L. HALL, recently Sales Engineer with the Baldwin Locomotive Works in San Francisco, has been transferred to the Baldwin plant in Eddystone, Pa., where he is serving in a similar capacity.

V. E. LYSAGHT has assumed direction of the sales of Andrew C. Campbell Div. of American Chain & Cable Co., Inc., Bridgeport, Conn., succeeding R. J. Southwell, resigned. For several years, Mr. Lysaght has been in charge of engineering and sales of "Rockwell" and "Tukon" hardness testers, manufactured by Wilson Mechanical Instrument Co., an associate company of American Chain & Cable Co., Inc. He will continue his duties with Wilson Mechanical Instrument Co.

FRANK B. DIANA, formerly Secretary and Works Manager, The Whipple & Choate Co., Bridgeport, Conn., is now Vice-President and General Manager, Z. Wagman and Son, Ltd., Toronto, Ont., Canada.

DR. JOHAN BJORKSTEN, President, The Bjorksten Research Laboratories, Chicago, has been elected by the Association of Consulting Chemists and Chemical Engineers, Inc., to serve as a Director of that organization for a period of two years.

H. O. HILL, Assistant Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Bethlehem, Pa., has been elected President of the American Welding Society for the year 1947–1948. Actively interested in the Welding Society for many years, and a member of many other technical and professional groups, Mr. Hill has been affiliated with A.S.T.M. since 1930, and is a member of Committees A-1 on Steel and A-5 on Corrosion.

ROBERT L. ZIEGFELD has been reelected Acting Secretary-Treasurer of the Metal Powder Association, New York City.

THE INTERNATIONAL HARVESTER CO., a Sustaining Member of A.S.T.M., is this year commemorating its 100th Anniversary. During the exercises and events in connection with this celebration the company arranged a most extensive exhibition at Soldiers' Field in Chicago during late October and early November. Those who visited the exhibition were well repaid for the time. In addition to a complete display of the wide range of farming equipment and related machinery available, all of which demonstrated the amazing advances that have been made, there were other displays featuring steel-making processes and various plant operations through which go the numerous products of the company. A member of the Society since 1902, the year of A.S.T.M. incorporation, the Company has been a Sustaining Member for many years. H. B. Knowlton, Materials and Standards Engineer, is the Society representative.

T. G. DELBRIDGE, formerly Manager of the Research and Development Dept., Atlantic Refining Co., Philadelphia, retired as of October 1, 1947. An outstanding authority in his field and widely known for his technical activities, Dr. Delbridge had been affiliated with this company since 1909. A Past-President of A.S.T.M., he was for many years Vice-Chairman of Committee D-2 on Petroleum Products and Lubricants. His contributions to the Society have been many and varied. He took an active interest in many A.S.T.M. projects and the Society owes a great deal to his long-time and sustained interest. He is making his home at 836 Wilde Ave., Drexel Hill, Pa., and is devoting his time to several hobbies.

HUGH W. FIELD, formerly Assistant Manager of the Research and Development Dept., has succeeded Dr. Delbridge as Manager of the Department. He has been with the Atlantic Refining Co. since 1928.

HEPPENSTALL CO., Pittsburgh, Pa., has recently completed its new $400,000 research building. Instead of a formal opening the Company has invited its friends and customers to inspect the research facilities through the medium of an illustrated booklet. This Company has held membership in A.S.T.M. since 1909, the present representative being J. A. Succop, Metallurgical Engineer. He is particularly active in the work of Committee A-1 on Steel.

HERMANN P. GOOD, Foundry Supt., Textile Machine Works, Reading, Pa., is among the incoming directors of the Gray Iron Founders' Society, which organization recently held its annual meeting in Milwaukee.

V. A. CROSBY, Metallurgical Engineer, Climax Molybdenum Co., Detroit has been chosen Vice-Chairman of the Gray Iron Division of American Foundrymen's Association. He will succeed R. G. McELWEE, Manager, Foundry Alloy Div., Vanadium Corporation of America, who recently assumed the chairmanship of the Gray Iron Division. Mr. Crosby will also head the division program and papers group which will organize the technical sessions to be sponsored at AFA's convention and foundry show in Philadelphia next May 3–7.

E. G. BAILEY, Vice-President, Babcock & Wilcox Co., New York, has been elected to be the next national president of The American Society of Mechanical Engineers.

CHARLES MAHONEY has been elected Vice-President and a Director of the William H. Bingham Co. Inc., Chicago. Before joining the Bingham Co. Mr. Mahoney maintained his own consulting organization which provided design, engineering and market counsel to metal and allied industries. During the war he was Chief Metallurgist and Metallurgical Superintendent of the Basic Magnesium, Inc., plant, near Las Vegas, Nev.

JESSE J. SHUMAN, long-time Testing Engineer of Jones & Laughlin Steel Corp., Pittsburgh, and an A.S.T.M. Honorary Member, suffered a stroke during the late summer at his cottage in Michigan. He is now at his home, 931 Sheridan Ave., East End, Pittsburgh 6, Pa. His two daughters who are with him advise that he is cheerful and can answer the telephone and gets around his room in a wheel chair. He would be pleased to hear from any A.S.T.M. members by mail or by 'phone in case members are in Pittsburgh. His 'phone number is Montrose 4266.

Another A.S.T.M. Honorary Member, J. O. LEECH, who spent the summer in Burnt Hills, near Schenectady, where his son is working for General Electric Co., has returned to Florida for the winter. He is located at 208 Redington Drive, St. Petersburg 8, Fla. Mr. Leech was in Pittsburgh in October and although he still is plagued somewhat with his heart condition he appeared quite good.

THEODORE A. WERKENTHIN, Principal Engineer, Civilian-in-charge of the Rubber and Plastics Section of the Bureau of Ships, U. S. Navy, has been appointed Chairman of the Federal Specification Technical Committee on Rubber Products, to succeed P. L. Wormeley who resigned after serving in that capacity for twenty-one years.

T. H. ROGERS has been promoted from Associate Director to Director of Research,

Standard Oil Co. of Indiana. Dr. Rogers has been with the company since 1922, and has been representative of the A.S.T.M. company membership for many years. He has served on many A.S.T.M. technical committees, notably committee D-2, and is a member of the Chicago District Council.

The hobbies and avocations of A.S.T.M. members are many and diversified, and the staff constantly comes across some of the hobbies which our members pursue. For example, MR. JOSEPH BROBSTON, President, Hercules Cement Corp., Philadelphia, had a most interesting display in a comprehensive exhibition in the Free Library of Philadelphia which was held in commemoration of the 100th Anniversary of United States Postage Stamps. Mr. Brobston's exhibit covered so-called encased postage stamps which came into usage as an emergency during the early Civil War period. Coins, particularly in small denominations, practically went out of existence, and someone conceived and patented the idea of using postage stamps laid in a small metal case covered with celluloid to protect them.

A. B. KINZEL, Chairman of the Board of the Engineering Foundation, New York has announced initiation of a four-phase study of pressure vessels, covering design, fabrication, testing, and inspection, this study being one of the largest projects sponsored by the Welding Research Council of the Foundation in a research program costing $75,000 a year, the principal financial support provided by interested manufacturers and users of pressure vessels. Chairman of the project's general committee, made up of 87 representatives of manufacturers and users of pressure vessels, insurance companies, educational institutions and government representatives, is Walter Samans of Sun Oil Co., Philadelphia. A central office for the Pressure Vessel Research Committee has been set up at 30 Church St., New York, where administrative work is carried on and research results correlated.

ANTHONY J. ZINO, JR., formerly with the Lubri-Zol Corp., was recently appointed Assistant Sales Manager, Industrial Sales Div., Swan-Finch Oil Corp., New York City. He is the present representative of Swan-Finch Corp. on A.S.T.M Committee D-2 on Petroleum Products and Lubricants.

LAWFORD H. FRY, long-time A.S.T.M. member and committee member, and Director of Research of the Steam Locomotive Research Institute, Inc., has announced change of address of the Institute to 30 Church St., New York 7, N. Y.

EDWIN L. HALL, has been newly appointed Director of the American Gas Association Testing Laboratories at Cleveland and Los Angeles.

JAMES S. VANICK, long-time A.S.T.M. member and member of Committee A-3, and Metallurgist with the Development & Research Div., International Nickel Co., New York City, has been named Chairman of the Gray Iron Division Research Committee of the American Foundrymen's Association.

DALE W. PATRICK, formerly Plant Metallurgist and Chief Inspector, Jones & Laughlin Steel Corp., has joined the personnel of the Colona Division, Pittsburgh Screw & Bolt Corp., Pittsburgh.

Under the recent reorganization plan of the Ethyl Corporation Research Laboratories, EARL BARTHOLOMEW continues as General Manager of the Laboratories, a position he has held since that office was created in 1945; and JOHN B. MACAULEY, formerly Engineer, is now Director of Research.

ROBERT H. HEDRICK, former Chemist at Purdue University, and recently Chemical Engineer with the Calvert Distilling Co., Clarion, Pa., is now Chemistry Instructor at Fenn College, Cleveland, Ohio.

ANTHONY L. ALESI, formerly in business for himself, is now Chemical Engineer, Princeton University, Princeton, N. J.

FRITZ S. ROSTLER has been appointed Director of Research and Development, Golden Bear Oil Co., Bakersfield, Calif. He was formerly on the faculty of the University of Delaware, Newark, as Research Professor of Chemistry.

DONALD W. HASKINS, previously Manager, Waterbury Div., Sheet Metal Manufacturing Co., Inc., Waterbury, Conn., is now a Partner in the A. L. Haskins Hardware Co., Wolfeboro, N. H.

DAT QUON PANG, recently Junior Civil Engineer, Materials Testing Lab., U. S. Engineer Dept., Honolulu, Hawaii, is now pursuing graduate studies at John Hopkins University, Baltimore, Md.

JOHN C. MOORE has been appointed Director, Scientific Section, National Paint, Varnish and Lacquer Assn., Inc., Washington, D. C. He was formerly Superintendent, Paint Plant, Sinclair Refining Co., Marcus Hook, Pa.

GEORGE F. HERRMANN, formerly Chemical Metallurgical Engineer, W. L. Maxson Corp., Norwich, Conn., is now Chemical Engineer, Ronson Art Metal Works, Inc., Newark, N. J.

SAMUEL B. WILDER, former Chief Chemist of the Mastic Asphalt Corp., South Bend, Ind., is now affiliated with the Great Lakes Carbon Corp., South Bend, as Sales Engineer.

FRANKLIN H. FOWLER, JR., is now Project Engineer, Lessells & Associates, Boston, Mass. He was formerly associated with the Curtiss-Wright Corp., Caldwell, N. J.

P. D. BROSSMAN, of E. I. du Pont de Nemours & Co., Inc., has been transferred from Arlington, N. J., to Parkersburg, W. Va., where he has been appointed Chief Chemist.

CHARLES D. SUSANO, formerly with the Tennessee Eastman Corp., Clinton Engineer Works, Knoxville, Tenn., is now Research Chemist, Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.

EVAN W. VAUGHAN, previously Senior Civil Engr., U. S. Engineer Office, Sacramento, Calif., is now Associate Professor of Structural Engineering, College of Applied Science, Syracuse University, Syracuse, N. Y.

H. R. DURBIN has retired as Chief Chemist of the Lone Star Cement Corp., New York City, being succeeded in that capacity by L. R. PRITCHARD. Mr. Durbin is a long-time affiliate of A.S.T.M., having held individual membership from 1919 to 1929 while associated with the Texas Portland Cement Co. and the International Cement Corp., and continuing from that year as representative of the International Corp., and of its successor, the Lone Star Corp.

JOSHUA L. MINER, long-time A.S.T.M. member, recently retired as Vice-President of the Atlas Lumnite Cement Corp. Affiliated with A.S.T.M. since 1912, Mr. Miner for many years had been a member of Committee C-1 on Cement and Committee E-8 on Nomenclature and Definitions. He plans temporarily to continue his work on the Administrative Committee on Standards.

H. V. CHURCHILL, Chief Chemist of the Aluminum Company of America, New Kensington, Pa., has been elected an officer of Rotary International for the fiscal year 1947–1948. He is a member of the Aims and Objects Committee of that organization. Mr. Churchill has served as a representative of ALCOA on various A.S.T.M. technical committees for many years.

MYRON A. SWAYZE, Director of Research, Lone Star Cement Corp., New York, has been appointed a Director of the American Concrete Institute, to succeed the late Roy R. Zipprodt.

PAUL MARTIN CHRISTENSEN, formerly Chief Engineer, Clark Controller Co., Cleveland, Ohio, is now Director of Research and Development, Federal Electric Products Co., Newark, N. J.

WILMER J. BALSTER is now affiliated with The Don L. Quinn Co., Chicago, Ill., as Technologist. He was previously connected with the Research and Development Laboratory, U. S. Army, Chicago.

On his recent trip to France, JOSEPH J. MATTIELLO, Vice-President and Technical Director of the Hilo Varnish Corp., Brooklyn, N. Y., and the 1946 A.S.T.M. Edgar Marburg Lecturer, was awarded the Legion of Honor of France, in recognition of his war activities and civilian service. Dr. Mattiello was attending the Technical International Congress.

WM. M. KINNEY, Vice-President and also General Manager and Secretary of the Portland Cement Association, retired on October 1, after almost thirty years of service with the P.C.A. Actively interested for many years in the work of A.S.T.M., Mr. Kinney has represented the P.C.A. membership in the Society since 1919. He has been connected with the portland cement industry practically all of his business life. Shortly after graduation from Lewis Institute as a mechanical engineer, he joined the staff of the Universal Portland Cement Company in 1907. In 1914 he was appointed Inspecting Engineer and Engineer, In-

formation Bureau of that company. In 1918 he was elected General Manager and Secretary of the Portland Cement Association, a position he held until 1931 when he was also elected Vice-President of the Association.

In connection with Mr. Kinney's retirement it is of interest to note that the journal *Pit and Quarry* in its July issue carried an article on the "45 Years of Service for the P.C.A." This included photographs of the officers and technical directors of the Association and other pertinent information.

NECROLOGY

J. EDWARD OPENSHAW, President, Openshaw & Bennett, Ltd., Montreal, Canada (July 8, 1947). Member since 1938.

MERTON T. ARCHER, Director of Research, The National Supply Co., Torrance, Calif. (October 26, 1947). A member of A.S.T.M. since 1915, Mr. Archer was a pioneer in the development of equipment for the petroleum industry. During the war, he was with the Army Ordnance Ferrous Metallurgical Advisory Board as a member of the Subcommittees on Gun Forgings and Cast Armor; and in 1945, he went to Chunking with the Donald Nelson mission as a consultant on metallurgical phases of China's war effort. He had recently returned from a four-month survey of oil field operations in South America.

ROBERT B. LEWIS, Chief Engineer, Tinius Olsen Testing Machine Co., Philadelphia, Pa. Representative of Olsen Co. on Committee D-20 on Plastics and several sections of Committee E-1 on Methods of Testing. Mr. Lewis had been for many years actively interested in A.S.T.M. work.

HOWARD AGNEW SMITH, Research Chemist, Fansteel Metallurgical Corp., North Chicago, Ill., since June, 1947, and for some years Metallurgical Engineer, Beech Aircraft Corp., Wichita, Kan. (October 26, 1947). Member since 1942.

H. G. ELLEDGE, Asst. to Director of Research, Diamond Alkali Co., Painesville, Ohio. Representative of Diamond Alkali Co. since 1937, and member of Committee D-12 on Soaps and Other Detergents.

PROFESSOR CHESTER A. HUGHES died suddenly on the morning of October 20. He had recently severed his connection with the University of Minnesota, and he and his family had moved to Lafayette, Ind., where he had accepted an appointment in the Department of Civil Engineering and Engineering Mechanics at Purdue University. He had been a member of A.S.T.M. since 1945.

Test for Waterproofness of Leather

A NEW TEST for the waterproofness of leather, developed in the leather laboratory of the National Bureau of Standards, subjects the leather to conditions which more nearly simulate actual use than former methods. Methods that have been previously used include measurements of the amount of water absorbed, the pressure required to force water through the leather, and the amount of water passing through the leather under a given pressure. None of these, however, is a direct measure of the waterproofness of leather and leather goods such as shoes that are ordinarily not subjected to high pressures of water or to immersion for any considerable length of time. Moreover, certain indications revealed by these tests do not agree with actual practice.

In the new test, leather specimens are continuously flexed by a specially designed machine while covered with water. The time, or the number of cycles required for water to penetrate a specimen is taken as the measure of its waterproofness. A slight variation of the test, the addition of dyes to the water, has permitted the course of the water to be traced, thus revealing the mechanism of water penetration. This is seen to occur through hair follicles at points of stress along the minute creases formed as the leather is flexed.

A large number of commercial shoe-upper leathers have been tested by the new method. These leathers show, in general, a low water resistance. The average resistance of a large number of samples is approximately 200 cycles or flexes, which would correspond to walking a distance of about ¼ mile. Stuffing the leather with large quantities of grease does not greatly improve the water resistance of leather until the amount of grease exceeds 50 per cent by weight. Leathers having grease contents in excess of 50 per cent are much more water resistant and may show resistances exceeding 10,000 flexes. Such leather, however, is not suitable for use in shoes or garments because of its impermeability to water vapor.

Leather having an appreciable water resistance at room temperature shows much less resistance at lower temperatures, probably due to increased stiffness and cracking of the greases at the reduced temperature. This finding indicates that waterproofing of shoes at moderate temperatures may be easier than at reduced temperatures.

In general, the studies show that leather offers higher resistance to penetration by water from the flesh side than from the grain side. The grain layer represents the principal water barrier and is more easily penetrated when in the normal position due to the higher stresses formed at the creases.

Waterproofing agents tested by the Bureau have been found to have little effect in waterproofing leather. Among those tested have been several of the new water-repellent materials whose application to shoe-upper leather generally results in slightly reducing rather than improving the water resistance. No material has been tested which has shown any promise in waterproofing shoe leather; however, some of these materials are effective for preserving the leather in storage and in service.

The Bureau waterproofness test has been developed for and applied principally to shoe-upper leather and appears to give concordant results in this application. Tests made using very soft, thin leathers, such as glove leather, show that there are other factors involved which render the test less reliable since reduced stresses on flexing cause such materials to appear relatively waterproof. It is probable that absorption or penetration under pressure is of much greater importance in these applications than penetration by flexing.

1947 British Plastics Year Book

THE latest (1947) edition of the British Plastics Year Book is intended to provide a classified guide to the plastics industry. Following the section devoted to "Editorial Content" including an extensive review of recent patents, there is a portion of the book devoted to materials, information on manufactured products, and on plant and equipment. Then follows a glossary of proprietary names and technical terms. Subsequent sections are devoted to lists of consultants and designers, and a directory of "Who's Who" in the plastics industry, with other information on associations and federations, and then a section on technical and general data. Copies of the publication can be obtained from the publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E. 1, England, at thirty shillings.

EMPLOYMENT

TECHNICAL HELP WANTED

C.—SALES ENGINEER: Graduate Engineer, not over 35 years, to represent manufacturer in sales of laboratory and precision equipment. Previous experience desired in sales of allied equipment for laboratory use of materials testing devices. Send outline of qualifications, education experience, etc. Address Box C, ASTM Bulletin, 1916 Race Street, Philadelphia 3, Pa.

Notes on Laboratory Supplies

Catalogs and Literature: Notes on New or Improved Apparatus

NOTE FROM THE EDITOR—In addition to a listing of catalogs and literature received at A.S.T.M. Headquarters, this column will in the future include notes of new and modified instruments. This information will be based largely on literature disseminated by apparatus manufacturers and laboratory supply houses. The purpose of this information in general is to post our members and BULLETIN readers on developments in the industry and to enable them to procure literature direct from the source.

Catalogs and Literature:

FISHER SCIENTIFIC CO., 717 Forbes St., Pittsburgh 19, Pa. A twelve-page leaflet entitled "pH—Its Measurement and Industrial Importance" presents in nontechnical terms a definition of pH, a discussion of its importance to industry and how pH measurements are made with an electric meter. Various commercial meters for Laboratory use also are presented. Illustrated.

Also, "Additional Modern Laboratory Appliances" is a supplement to Catalog 90. The supplement presents equipment and supplies which have been introduced since the publication of the general catalog. It contains many appliances designed in the Fisher-E. & A. Development Laboratories, manufactured in the Fisher-E. & A. Shops. 76 pages. Illustrated.

BURRELL TECHNICAL SUPPLY CO., 1942 Fifth Ave., Pittsburgh 19, Pa. A four-page leaflet describing the Larrabee Titrator, an instrument for the electrometric detection of end points in titrations involving oxidation and reduction reactions. Of special interest to steel analysists. Illustrated.

Also, Catalog No. 247, "Laboratory Chemicals." 72 pages. Describes "Difco" Culture Media and Reagents; Chemicals for Steel Analysis by Combustion; "Baker's Analyzed" C.P. Reagent Chemicals; Gas Analysis Reagents. Illustrated.

EASTMAN KODAK CO., Rochester 4, N. Y. An eight-page booklet entitled "Kodagraph Autopositive Paper—The Big News Plus in Engineering Drawing Reproduction." This new paper brings the advantages of photography to your direct process or blueprint equipment. Illustrated.

Also, the 175-page catalog and price list of Eastman Organic Chemicals which indicates the tremendous number of these that are available. This publication gives the name, catalog number, and price of the various chemicals. A copy of the list can be procured by writing to the Organic Chemical Sales Division, Rochester 4, N. Y.

PIEZO MANUFACTURING CORP., 110 East 42nd St., New York 17, N. Y. A twelve-page booklet "Piezo Oil Gaging Equipment," Catalog 57, describes oil gaging steel tape, tank car gaging pole, metal gaging pole, wood gaging pole, cup case thermometer, oil sampling equipment and special equipment. Illustrated.

HARRY W. DIETERT CO., 9330 Roselawn Ave., Detroit 4, Mich. A four-page leaflet entitled "Moistmeter" illustrates and describes the No. 285 Moistmeter. Illustrates rapid determination of moisture in sand on floor and of moisture in sand in sample container or sand bins.

Also, a twelve-page booklet entitled "Carbon and Sulfur Analysis." Illustrates and describes various pieces of equipment such as the two-minute carbon determinator, cast metal specimen mold, purifying train, carbon combustion tubes liner shield, sulfur determinator, oxygen drying tower, etc.

THE GAERTNER SCIENTIFIC CORP., 1201 Wrightwood Ave., Chicago 14, Ill. Bulletin 140-74, "Gaertner Dilatation Interferometer" an eight-page booklet describing this instrument for determining with high precision the coefficient of thermal expansion of small metallic, ceramic or plastic samples at temperatures up to 1000 C. Bulletin also describes equipment for measuring setting expansion of dental and other amalgams, and illustrates a special dial-and-quartz-tube type of dilatometer. Illustrated.

HENRY A. GARDNER LABORATORY, INC., 4723 Elm St., Bethesda, Md. A six-page folder describing the new Hunter photometric unit and exposure heads to measure reflectance, gloss, and other features of appearance. Folder gives variety of applications, plan of apparatus, operating procedure, specimens, precision and accuracy, etc. Illustrated.

THE BALDWIN LOCOMOTIVE WORKS, Philadelphia, Pa. "Baldwin Sonntag Impact Machines," Bulletin 253, describes these impact machines including the adaptation for evaluating plastics. The latter had five ranges from 10 to 48 ft-lb. with a special dial to permit accurate readings.

Instrument Notes:

DUAL RECORDOMATIC TITRATOR—Precision Scientific Co., 228 N. La Salle St., Chicago 1, Ill. What is indicated as the first dual automatic recording device for plotting automatic titration curves, has just been announced by Precision Scientific Co. The device provides a permanent and complete record of titration curves, easily reproducible and indicated as superior to the curves obtained manually. It eliminates all work on part of operator, except that of preparing solutions and loading the feed unit. While one sample is being titrated, a second sample may be prepared for analysis. The "Precision"-Dow Dual Recordomatic Titrator is recommended for routine control work, as well as experimental research in chemical, industrial, and petroleum laboratories; for studying new reactions; for determining suitable indicators, for acidity determinations on petroleum products according to A.S.T.M. Method D 664; for Mercaptan determinations, among its many potential uses. The Titrator is equally well suited for aqueous and nonaqueous media. It can be used with silver, antimony, platinum, calomel, or glass electrodes, it is reported. The instrument consists of two parts: (1) a reagent-feeding device, and (2) a recording potentiometer.

FOTO-MARKER—Millen Manufacturing Division, P. O. Box 3911, Detroit 27, Mich. The Foto-Marker is a device for printing identifying numbers on photographic materials. The photographic film, plate, or printing paper is placed over a ¼-in. by 1-in. aperture in the top of the unit. A switch is closed which projects the image of a mechanical counter onto the emulsion. Thus, when the emulsion is developed, the serial number of the exposure appears as white numerals centered on a dark background measuring approximately ¼ in. by 1 in. The mechanical counter is reversible and has a range of 00000 to 99999. A lever is provided for advancing the counter one digit between exposures.

WILDER PROJECTOR (Model B) and Wilder Optical Comparator—George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y. This projector is being introduced to industry as an entirely new design of Optical Bench Comparator for the rapid inspection of mass-produced parts as occur in watch, clock, instrument, radio, electrical, screw products, stamping and similar manufacture. To guarantee maximum speed of operation, the work stage is in natural, namely horizontal position. To guarantee maximum convenience of observation, the large screen is in slightly inclined vertical position. Both the screen and the stage are next to each other, within easy reach of the operator, and unobstructed by the lamphouse or other unit.

THE THWING-ALBERT ELECTRONIC % MOISTURE METER—Thwing-Albert Instrument Co., Penn St. and Pulaski Ave., Philadelphia 44, Pa. This Moisture Meter is a battery operated instrument which measures the resistance to the flow of an electric current, this resistance changing with the moisture content of the material being tested. The current flow through the meter is amplified by the use of an electronic circuit, and the readings are indicated on a scale reading directly in terms of per cent moisture. The Moisture Meter is calibrated by weighing the material to be tested, and then measuring its electrical resistance. The instrument is readied for operation by means of one simple adjustment, which suffices for several hours of operation. Tests are made by pushing the points of the probe into the material, or holding the points against a surface with a steady pressure. No dangerous voltages are employed anywhere in the instrument. By making suitable calibrations, the instrument can be used for determining the per cent moisture in a variety of materials. A comparison made between the Moisture Meter readings for paper, and oven test results for the same material showed a maximum difference of 1 per cent in the range from 7 to 25 per cent moisture. The reproducibility of the Moisture Meter results compares favorably with that of oven testing, which is known to have an inherent error of from 1 to 25 per cent. The Moisture Meter has been designed for use as an industrial production tool, rather than a laboratory instrument. Except in cases requiring special calibrations, shipment should be made in approximately two weeks.

G-10 LABORATORY BOX FURNACE—Lindberg Engineering Co., 2450 West Hubbard St., Chicago 12, Ill. A new box type laboratory furnace with temperatures up to 3000 F. top heat, and for continuous operation as high as 2500 F. has been developed by Lindberg Engineering Co. This self-contained unit may also be used as a muffle furnace, or with carbon blocks for nonoxidizing atmospheres. Furnace temperatures are regulated by an indicating-controlling pyrometer with electronic circuit. For further information on the G-10 Laboratory Furnace, request Bulletin No. 980.

The Motor-Driven Grease Worker and Its Application for Evaluating Consistency Stability of Lubricating Greases[1]

Report of Section II on Consistency Measurements and Related Physical Tests for Lubricating Greases of Technical Committee G on Lubricating Grease of Committee D-2 on Petroleum Products and Lubricants

Prepared by Carl W. Georgi[2]

Most lubricating greases become softer and acquire a lower consistency upon being subjected to working. This working may be considered as any handling or movement of the grease, such as filling of dispensers or guns, pumping through hoses, pipe lines, or fittings, as well as actual use in lubricating bearings or other mechanisms.

The scope of A.S.T.M. Tentative Method of Test for Cone Penetration of Lubricating Grease (D 217 – 47 T),[3] contains several pertinent statements pertaining to working of greases and is quoted as follows:

"*Scope:*

"1. (*a*) This method describes three test procedures for the empirical estimation of the consistency of lubricating greases by measurement of the extent of penetration of a standard cone. The method is applicable to a variety of greases since it describes prodedures for the measurement of worked penetration, of unworked penetration, and of block penetration. Penetrations up to 400, the practical limit of the cone, may be measured.

"(*b*) Unworked penetrations are affected by a number of factors which are difficult to control. They do not generally represent the consistency of greases in use as effectively as worked penetrations, which should be preferred wherever practicable, for evaluating lubricating greases.

"NOTE 1.—The unworked penetration of a grease may not be a reliable measure of its consistency in its original state of manufacture. Any transferring or other manipulating of grease subsequent to manufacture tends to affect the unworked penetration by amounts depending on the type of the grease and the handling it is given."

As mentioned, unworked penetration tests may be unreliable since different types of greases vary considerably in the degree to which they undergo consistency change upon being worked. As a result, worked penetrations are preferred, and A.S.T.M. Method D 217 – 47 T calls for a 60-stroke working of the grease sample in the standard worker immediately prior to making cone penetration tests. It is generally recognized, however, that working of a grease sample for 60 strokes in the A.S.T.M. worker does not portray the complete story of the consistency stability of the grease. This is illustrated by Fig. 1 which shows consistency-working curves of four typical types of lubricating greases. Greases A and B are quite stable to working and display only moderate change or softening on working up to 1000 strokes in the A.S.T.M. worker. Grease C softened markedly up to 300 strokes working after which it became relatively stable, whereas grease D displays progressive softening upon continued working with no indication of an "equilibrium point."

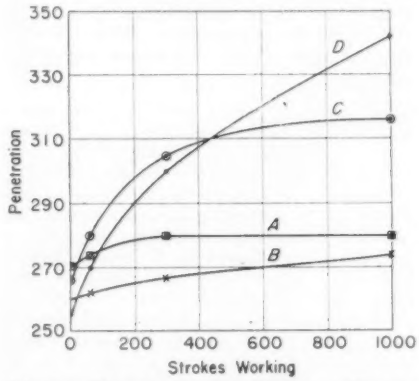


Fig. 1.—Penetration (Consistency) Change with Working in A.S.T.M. Grease Worker, Typical Types of Lubricating Greases.

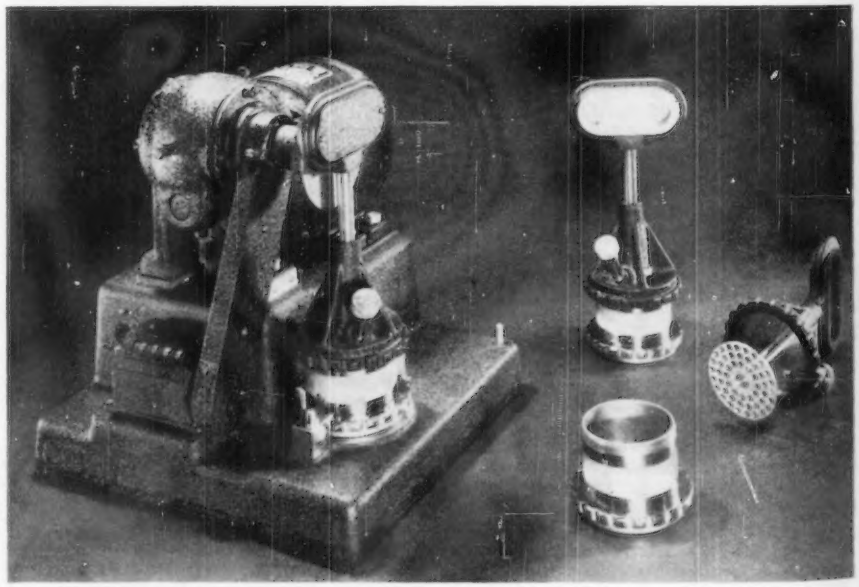


Fig. 2.—Motor-Drive Unit with Workers of A.S.T.M. Dimensions Modified for Mechanical Rather than Hand Operation.

Courtesy of Precision Scientific Co.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at a meeting of Technical Committee G on Lubricating Grease held in Washington, D.C., January 17, 1947.

[2] Technical Director, Research Lab., Quaker State Oil Refining Corp., Buffalo, N. Y.

[3] 1947 Supplement to A.S.T.M. Book of Standards, Part III-A, p. 139.

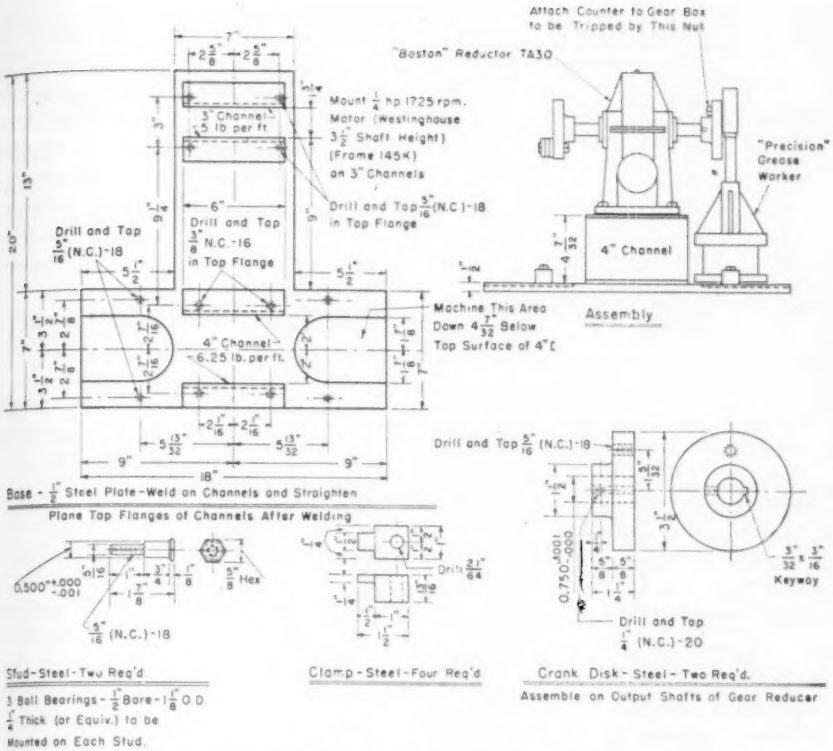

Attach Counter to Gear Box to be Tripped by This Nut
"Boston" Reductor TA30
"Precision" Grease Worker
Mount ¼ hp 1725 rpm. Motor (Westinghouse 3½" Shaft Height) (Frame 145K) on 3" Channels
3" Channel 5 lb per ft
Drill and Tap ⅜" (N.C.)-18 in Top Flange
Drill and Tap ⅝" N.C.-16 in Top Flange
Drill and Tap 5/16" (N.C.)-18
4" Channel
Assembly
Machine This Area Down 4 7/32" Below Top Surface of 4" C
4" Channel 6.25 lb per ft
Drill and Tap 5/16" (N.C.)-18
Keyway
Drill and Tap ¼" (N.C.)-20
Base - ½" Steel Plate - Weld on Channels and Straighten Plane Top Flanges of Channels After Welding
Stud - Steel - Two Req'd
3 Ball Bearings - ½" Bore - 1⅛" O.D. ¼" Thick (or Equiv.) to be Mounted on Each Stud.
Clamp - Steel - Four Req'd.
Crank Disk - Steel - Two Req'd. Assemble on Output Shafts of Gear Reducer

Fig. 3.—Schematic Drawing of Motor-Drive Design to Accommodate Two Workers.
Courtesy of Foote Mineral Co.

Because of the varied nature of lubricating greases in their reaction to extended working, many laboratories have adopted as more or less standard practice worked penetration tests after working up to 5000 or 10,000 strokes and in some instances as high as 100,000 strokes. Figure 2 illustrates a motor drive unit together with workers of A.S.-T.M. dimensions, but modified for mechanical rather than hand operation, as commonly used for such motorized working tests. Figure 3 is a drawing of another design of motor drive which accommodates two workers.

In view of the rather wide interest in motorized working of greases for intervals considerably longer than the 60 strokes specified in Method D 217, Technical Committee G on Lubricating Grease of Committee D-2 on Petroleum Products and Lubricants instituted a cooperative test program to explore the general subject. Three reference grease samples were distributed for cooperative testing:

Sample GII-2...No. 1 consistency, calcium-base grease, (U. S. Army Specification 2-107 Type).
Sample GII-3...No. 2 consistency, soda-base grease, (U. S. Army Specification 2-108B Type).
Sample GII-4...No. 3 consistency, soda-base grease, high-viscosity mineral oil.

Fourteen laboratories submitted test results on motorized working of the three reference samples, with working up to 10,000 strokes. Several of the laboratories ran repeat tests on different dates so that a total of 19 sets of data on each grease sample were supplied. Table I summarizes the results. For comparison, Table II lists unworked and worked (60 strokes) penetration tests on the same greases by the standard A.S.-T.M. Method D 217 (results from 18 cooperating laboratories).

The motorized worker tests show in general somewhat poorer interlaboratory reproducibility than the regular penetration tests performed according to Method D 217, particularly with working above 300 strokes. This poorer degree of reproducibility is probably due to the higher temperatures developed in the grease samples during extended working, as shown in Table III. Temperature rise in the grease samples became quite significant in many of the tests reported, particularly with the longer working intervals. Two opposing factors are thus involved in motorized working. First, long working induces considerably higher grease temperatures than the 77 ± 3 F. specified for penetration testing in Method D 217. This may readily produce softer greases and correspondingly higher penetration readings. Second, the grease sample must be tested as soon as possible after working so that there will be no "set-back," as could be the case if a warmed-up worked sample were cooled down to 77 F. prior to penetration testing. Evidently some of the cooperating laboratories made

TABLE I.—SUMMARY OF RESULTS OF COOPERATIVE PENETRATION TESTS—MOTORIZED WORKING OF REFERENCE GREASE SAMPLES.

	60 Strokes	300 Strokes	1000 Strokes	5000 Strokes	10 000 Strokes
Grease GII-2					
Average penetration, 19 tests	325	330	330	330	330
Maximum penetration	330	334	339	343	345
Minimum penetration	318	319	321	319	320
Spread	12	15	18	24	25
Percentage of Tests Within:					
± 5 Points of average	82	77	65	59	59
±10 Points of average	100	94	100	77	88
±15 Points of average	...	100	...	100	100
Grease GII-3					
Average penetration, 19 tests	275	305	325	345	350
Maximum penetration	288	327	341	359	362
Minimum penetration	264	273	306	326	334
Spread	24	54	35	33	28
Percentage of Tests Within:					
± 5 Points of average	47	41	29	47	47
±10 Points of average	77	65	70	70	82
±15 Points of average	100	82	88	94	94
Grease GII-4					
Average penetration, 19 tests	240	250	260	275	285
Maximum penetration	251	263	283	305	308
Minimum penetration	228	239	246	256	266
Spread	23	24	37	49	42
Percentage of Tests Within:					
± 5 Points of average	59	65	41	35	29
±10 Points of average	82	82	70	65	77
±15 Points of average	100	100	88	77	82

TABLE II.—SUMMARY OF RESULTS OF COOPERATIVE PENETRATION TESTS—UNWORKED AND WORKED PENETRATIONS BY A.S.T.M. METHOD D 217.

	GII-2	GII-3	GII-4
Summary of Unworked Penetration Tests			
Average penetration, 34 tests	320	225	220
Maximum penetration	328	236	234
Minimum penetration	304	210	208
Spread	24	26	26
Percentage of Tests Within:			
± 5 Points of average	65	68	47
±10 Points of average	95	91	73
±15 Points of average	100	100	100
Summary of Worked Penetration Tests (60 Strokes)			
Average penetration, 34 tests	325	280	240
Maximum penetration	333	296	255
Minimum penetration	311	266	230
Spread	22	30	25
Percentage of Tests Within:			
± 5 Points of average	68	62	56
±10 Points of average	95	86	89
±15 Points of average	100	97	100

TABLE III.—COOPERATIVE MOTORIZED WORKER TESTS—TEMPERATURE RISE AND TEST TEMPERATURES REPORTED BY COOPERATING LABORATORIES.

Temperature Rise, deg. Fahr.	No. of Tests				
	60 Strokes	300 Strokes	1000 Strokes	5000 Strokes	10 000 Strokes
Temperature Rise of Grease Sample During Working					
0	9	10	7	6	6
1 to 4	30	17	9	2	5
5 to 8	10	15	20	10	6
9 to 12	3	6	6	10	13
13 to 16	..	3	6	10	11
17 to 20	..	..	3	5	3
21 to 24	..	..	..	5	3
25 to 30	..	..	..	2	5
Grease Sample Temperatures When Penetration Tested After Working					
71 to 75	7	..	..	..	..
81 to 84	4	6	8	4	6
85 to 88	..	2	5	12	7
89 to 92	..	4	1	3	6
93 to 96	..	2	1	4	5
97 to 100	..	1	1	1	2
100 to 110	..	..	..	2	2
	(All other tests made at 77 ± 3 F.)				

some provision for cooling the grease samples either during or after the motor working intervals, whereas others worked the greases and then made the penetration tests immediately thereafter with temperatures as developed. A detailed study of the cooperative test data indicates that inter-laboratory reproducibility with the motor-worked penetration tests was as good as that attainable with the regular Method D 217 when the worked samples were maintained below about 87 F. (10 F. rise). When the samples warmed up above about 90 F., penetration readings tended to be higher than average and caused greater spread and poorer reproducibility of test results. This tends to be confirmed by several of the cooperating laboratories who supplied comparative test data on 60-stroke, worked consistencies using both hand and motor working, as summarized in Table IV. With only 60-stroke working, excessive temperature rise was not a factor, and the test results with either hand or motor working agree well within the limits of test reproducibility.

It would appear accordingly, with adequate provision for controlling grease temperatures in a properly limited range, the motorized worker test can be as reproducible within and between laboratories as regular penetration tests made according to Method D 217. However, considerable additional cooperative test and development work would be necessary before this end could be achieved. In its present state of development, the procedure for motorized working of greases for longer than 60 strokes is not sufficiently precise or reproducible to be included as a part of Method D 217. The results of the cooperative tests are accordingly being reported herein so that the information secured to date will be available to those interested.

It seems desirable to mention at this point that worked penetration tests on greases for intervals of several thousand strokes require careful and cautious interpretation. Lubricating greases vary greatly in consistency stability or resistance to softening on working, as illustrated by Fig. 1, depending largely upon the kind and concentration of soap, the viscosity of the mineral oil constituent, and the details of processing during manufacture. Certain types of greases inherently have high resistance to softening on extended working, whereas other types inherently have quite limited resistance, but this factor alone, without considering many other important physical and performance properties, will not distinguish between a suitable or satisfactory lubricant for a given application and one which would be undesirable. While it might be considered at first glance that a grease displaying essentially no consistency change in motorized working tests might be the most desirable, this sort of conclusion may in many cases be quite incorrect. In many applications it is desirable that the grease soften and attain a state of near fluidity on the surfaces actually being lubricated. In fact, one of the reasons grease lubrication may be preferred over fluid oil may be

TABLE IV.—COMPARISON OF 60-STROKE WORKED CONSISTENCIES WITH HAND AND MOTOR-DRIVEN WORKERS.

Laboratory	Penetration Readings					
	GII-2		GII-3		GII-4	
	Hand Worked	Motor Worked	Hand Worked	Motor Worked	Hand Worked	Motor Worked
P-1	324 333	328 330	280 274	268 272	244 243	240 246
P-3	317 322	318 318	269 270	266 271	230 232	235 243
P-8	317 320	319	267 279	264	237 241	246
P-13	328	325 322	280	267 266	249	238 242
P-14	325	330	282	276	234	238
P-15	313 322	324 324	284 285	287 283	233 234	239 238

TABLE V.—COMPARISON OF MOTOR WORKER TESTS WITH A.S.T.M. WORKER PLATE AND MODIFIED WORKER PLATE.

Strokes Working	Penetration Readings			
	Grease GII-2		Grease GII-4	
	A.S.T.M. Plate, 51 Holes, 1/4 in.	Modified Plate 325 Holes, 1/16 in.	A.S.T.M. Plate, 51 Holes, 1/4 in.	Modified plate 325 Holes, 1/16 in.
60	326	328	241	243
300	330	330	257	252
1 000	332	330	265	278
5 000	335	334	280	316
10 000	335	334	285	330
100 000	337	346	310	

that most greases retain their body or consistency only at points adjacent to and surrounding the lubricated moving parts and thus act as a seal to exclude dirt and moisture and to resist leakage. On the other hand, the grease feeding into and actually supplying the lubrication at the bearing surfaces is subjected to very high shear rates and may soften to the point of supplying essentially fluid film lubrication with a minimum of viscous friction. As an additional factor, working even for many thousands of strokes in the A.S.T.M. worker might be the equivalent of only a few minutes of use in a bearing or similar close-fitted mechanism, since the rates of shear exerted in the A.S.T.M. worker are in the order of a few hundred reciprocal seconds at most, while the shear rates in an actual bearing may run into many thousand reciprocal seconds. Similarly, in service grease is normally subjected to considerable temperature variation, heating up during running and cooling off during idle periods. Such alternating cycles of heating and cooling may have a pronounced effect on the grease consistency and consistency change which is not measured or evaluated by motorized worker tests wherein temperature fluctuation is in the order of only 10 to 30 F. and wherein temperature cycling is not encountered. In view of these considerations, many grease technologists have mentioned that motorized working tests have limited significance unless such have been carefully correlated with the particular application in question.

Modified Grease Worker with 1/16-in. Holes in Worker Plate

Certain grease specifications of the Federal Government agencies include a working test wherein the sample is motor worked for 100,000 strokes in a modified A.S.T.M. grease worker, the modification consisting of a worker plate containing approximately 325 holes of 1/16-in. diameter instead of the customary 50 to 55 holes of 1/4-in. diameter.

One of the cooperating laboratories supplied comparative data on two of the reference grease samples, using the standard worker and the modified worker. Table V summarizes the test results. Grease GII-2, which possesses high resistance to breakdown on working, gave practically identical penetration test values with both worker plates. Grease GII-4, which has relatively poorer resistance to consistency change on working, displays a considerable difference in penetration change on working in the two types of workers. It is interesting that working of GII-4 for 100,000 strokes with the standard worker having 51 holes of 1/4-in. diameter produced somewhat less softening of the grease than only 10,000 strokes working with the modified worker having 325 holes of 1/16-in. diameter.

Although the amount of test data comparing the standard worker with the modified unit is limited, it appears with greases having good resistance to breakdown on working, the number and size of holes in the worker plate make no material difference. With greases which are quite susceptible to consistency change on working it appears, however, that the number and size of holes in the worker plate have a significant effect on the results secured.

Improvements in A.S.T.M. Grease Worker

A by-product of the cooperative test program on motor working was the accumulation of experience which indicated a need for improvements in the design of the A.S.T.M.

Fig. 4.—New Grease Worker Incorporating Design Improvements.
Courtesy Precision Scientific Co.

grease worker as originally specified in Method D 217 – 44 T.[4]

1. A pet-cock or surge tube should be incorporated on the worker cover to relieve pressure and to minimize inclusion of air in the grease sample during working.

2. The worker cover should be recessed to accommodate the worker plate and to leave the cup full of grease after the working period.

3. A single, large diameter plunger shaft and a heavier perforated plate should be incorporated to overcome weakness of construction as noticed particularly when working harder greases.

4. A packing gland should be added to the worker cover around the plunger to compensate for wear and to minimize inclusion of air or grease leakage.

5. Heavier threads or a bolted closure are desired to minimize crossing or stripping the threads, as sometimes encountered with the original worker.

6. The worker cup should be of one piece cast construction or welded to avoid breakage at the juncture of the base and the walls.

All of these design improvements have been incorporated in the new worker as specified in Method D 217 – 47 T, and as shown in Fig. 4. The new worker is also designed so that it may be operated by hand or by a motor drive unit.

[4] 1946 Book of A.S.T.M. Standards, Part III-A, p. 846.

Cooperating Laboratories:

Air Material Command
Wright Field
California Research
Corp. ..... B. B. Farrington
Cities Service Oil Co. .... T. E. DeVilliers
Pure Oil Co. ..... J. B. Stucker
Quaker State Oil Refining Corp. ..... C. W. Georgi
Rock Island Arsenal,
U. S. Army Ordnance
Dept.
Sinclair Refining Co. ..... N. J. Gothard
Socony-Vacuum Oil Co. . T. G. Roehner
Standard Oil Co. (Ind.) . E. W. Adams
Standard Oil Co. (Ohio) . F. J. Sanders
Swan-Finch Oil Corp. .... W. C. Bryant
Texas Company ..... Gus Kaufman
Union Oil Co. of California ..... L. W. McLennan
U. S. Navy Engineering
Experiment Station

Penetration of Block Greases[1]

By L. C. Brunstrum[2] and A. W. Weitkamp[2]

SYNOPSIS

A study of A.S.T.M. penetration values obtained on hard greases revealed that the results were critically dependent on the dimensions of the cone tip. The significant measure was found to be the cross-sectional area of the cone tip at the surface of the penetrated grease cake. The depth of penetration is a convenient though indirect measure of the cross-section. It follows that close dimensional tolerances must be employed in the manufacture of the tips if reproducible results are to be obtained.

In a recently completed cooperative program aimed at the improvement of the cone penetration method, thirteen laboratories tested five block greases under conditions as nearly identical as possible. Each laboratory used the approved A.S.T.M. grease penetrometer specified in A.S.T.M. Method D 217.[3] The following laboratories cooperated: Quaker State Oil Refining Corp., Sinclair Refining Co., Standard Oil Co. (Ohio), Socony-Vacuum Oil Co., The Texas Company, Cities Service Oil Co., California Research Corp., Rock Island Arsenal, Union Oil Co. of California, Imperial Oil Co., Bendix Aviation Corp., Gulf Research and Development Co., and Standard Oil Co. (Indiana).

In Table I are listed the penetration values reported by the thirteen laboratories using specimens from a single block of each of the five block greases. Penetration numbers are arranged at the head of each tabulation and a code number corresponding to each laboratory is entered in the table under the appropriate penetration number for each grease. Each result is the rounded average of nine readings, three being taken on each of three adjacent sides of a carefully prepared cubical specimen. It will be noted that most of the results fall within 3 or 4 point ranges and that the laboratories reporting higher or lower results were quite consistently high or low. Laboratories Nos. 5, 12, and 13 each submitted two sets of results. The duplicate data from laboratory No. 13 were obtained by one operator using a single instrument but with

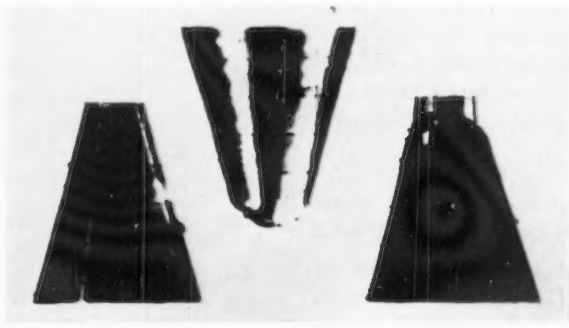


Fig. 1.—Photomicrographs of the Tips of the Cones.

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[1] Data presented at a meeting of Technical Committee G on Lubricating Grease held in Washington, D.C., January 17, 1947.

[2] Group Leader and Senior Project Chemist, respectively, Standard Oil Co. (Indiana), Whiting, Ind.

[3] Tentative Method of Test for Consistency of Lubricating Greases and Petrolatum (D217-44 T), 1946 Book of A.S.T.M. Standards, Part III-A, p. 846.

TABLE I.—COOPERATIVE PENETRATION DATA.

G-II-J

Penetration	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Laboratory (Original)	7					5	3 11	5	1 13A 8	6	10 12	13 12A	2	4 9
(Corrected)											7 2			

G-II-K

Penetration	9	10	11	12	13	14	15	16	17	18	19	20
Laboratory (Original)	7						3 6 8	5A 9 13A	1 4 12A	10 12 13		2
(Corrected)										2	7	

G-II-L

Penetration	23	25	26	27	28	29	30	31	32	33	34	35	36	37
Laboratory (Original)	7					3	1 11 8		6		5 5A 9 10 12 12A 13A	2 4 13		
(Corrected)										7 2				

G-II-M

Penetration	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Laboratory (Original)	7				11			1 3 8			5 5A	9 10 13A	4 12 12A 13		2
(Corrected)											7		2		

G-II-N

Penetration	12	13	14	15	16	17	18	19	20	21	22	23
Laboratory (Original)	7			11	6	3	1 8	5 5A 12	4 9 12A 13A	2 10 13		
(Corrected)								2			7	

one new and one old cone tip. These tips will be referred to below as tips *N* and *O*, respectively.

Detailed results listed in Table II show the precision obtainable with tips *N* and *O* on any given face of each specimen. Slight differences to be noted between different faces of a given specimen serve only to emphasize the need for averaging values over three adjacent faces. It seemed significant that tip *O* consistently gave lower penetration, by about two penetration units, than tip *N*. Microscopic examination of the tips revealed that tip *O* had been chipped and had an abnormally sharp point, whereas tip *N* was a new tip well within the dimensional tolerances of Method D 217.

Photomicrographs of the tips are shown in Fig. 1. Tip *N* is at the left, and tip *O* in the middle. The images of tips *N* and *O* are shown superimposed at the right. The difference in length of the two tips is approximately 0.2 mm. or two penetration units. This striking correlation with the penetrations actually observed seemed to indicate that the sharpness or contour of the point has little effect on the penetration except in so far as it affects the setting of the penetrometer at the start of the test. Since the angles of tips *N* and *O* were identical it follows that these tips came to rest in any given specimen at equal projected cross-sectional areas. The results with tip *O* were less than those with tip *N* because any given cross-section is about 0.2 mm. nearer the point.

In order to test the effect of excessive truncation, tip *O* was repeatedly ground down and tested against a single face of a given sample of grease. Seven such grindings were made and each time the tip was found to come to rest in the test specimen at the same cross-sectional area. In Fig. 2 is a series of photomicrographs, beginning at the left with a perfect new tip and showing in sequence the seven successive grinds of tip *O*. The base line common to all of the tips shows the depth of penetration into the test specimen. After the seventh grind two additional grinds were performed which served to sharpen the tip but not to shorten it. Photomicrographs are shown in Fig. 3. Subsequently, additional flat grinds were made until a tip area was reached at which the cone simply rested on the sample surface without appreciably penetrating it. Photomicrographs of the last grinds were not made because the field of view of the microscope was too small. However, in Fig. 4 is a sketch showing schematically all of the tip shapes. *T* is the dimension from the theoretical apex to the flat end of the cone after each grind; *P* represents the average of three penetrations on a single small sample; *C* is equal to the sum of *T* and *P* and is the distance from apex to the cross-section at which the cone

TABLE II.—ACTUAL PENETRATION DATA, LABORATORY NO. 13

Sample	Tip *N*			Tip *O*			
	Top	Side	End	Top	Side	End	Difference
G-II-J.....	25 26 25	25 25 25	25 26 25	23 23 24	23 22 22	22 22 22	
Average....		25.2			22.6		2.6
G-II-K.....	18 19 18	18 17 17	19 19 18	16 15 15	16 16 17	17 16 16	
Average....		18.1			16.0		2.1
G-II-L.....	35 34 35	35 36 36	35 35 35	34 34 35	34 34 34	34 34 34	
Average....		35.1			34.1		1.0
G-II-M.....	29 30 29	30 30 30	29 29 30	28 28 28	28 28 28	28 28 28	
Average....		29.6			28.0		1.6
G-II-N.....	21 21 21	20 21 20	21 21 20	19 20 20	19 19 20	21 21 21	
Average....		20.7			20.0		0.7

Fig. 2.—Photomicrographs Showing Perfect New Tip (Left) and Seven Successive Grinds of Tip *O*.

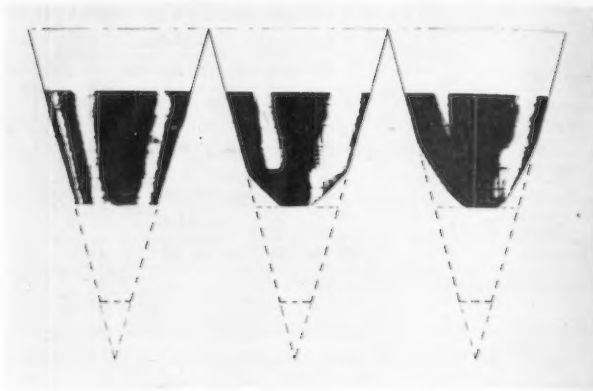

Fig. 3.—Photomicrographs Showing (Left) Seventh Grind of Tip *O*, and Two Additional Grinds Made to Sharpen, but Not Shorten the Tip.

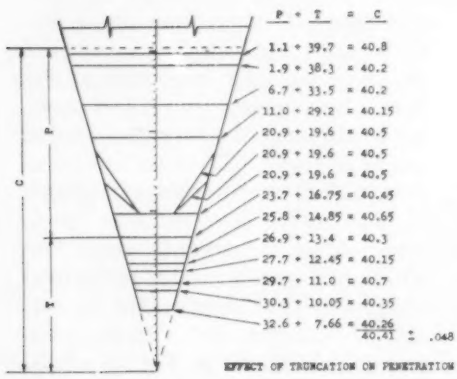

Fig. 4.—Schematic Diagram of All the Tip Shapes.

P = average of three penetrations on a single small sample.
T = dimension from theoretical apex to the flat end of the cone after each grind.
C = sum of *P* and *T*, and its distance from apex to cross-section at which cone stops penetrating.

stops penetrating. The data used in constructing this diagram are shown in Table III. The constancy of the value of *C* for the twelve cone lengths, including two with sharpened points, is taken as proof that:

1. For a given sample of block grease any cone stops penetrating at a certain cross-sectional area.

2. The penetration as reported under Method D 217 is the distance from the truncated end to this area.

3. The sharpness of the tip is of no importance except to the extent that it affects the original setting of the tip on the sample surface.

Laboratory No. 7 is one that consistently reported low values. By subsequent actual measurement the diameter of the truncated tip used by laboratory No. 7 was 0.035 in. and the cone angle was 27 deg. This is equivalent to an excessive truncation of about 10 penetration units for the products tested. If this correction is added to the penetrations originally reported by laboratory No. 7 the penetrations of this laboratory fall in line with the majority as shown by the corrected values in Table I.

On the other hand, laboratory No. 2 reported high values and we might assume that its tip had not been truncated to the extent required by Method D 217. Examination under the microscope disclosed that it had been damaged and reground to a sharper angle, the new angle extending well up along the tip. Therefore, no direct correction can be made. However, it is possible to calculate the area of the cross-section of the cone at the point of penetration. This area would occur about 0.2 mm. too far up on the tip compared to a standard tip. The results of laboratory No. 2 are also in line if corrected by this amount. It is likely that the results from the remaining laboratories could be similarly corrected.

It was concluded that Method D 217 will be entirely satisfactory for block greases if the cone tips are periodically measured for conformity, and lower tolerances on the tip are required in the revised method.[4]

The tip manufacturer was consulted as to his ability to supply cone tips of lower tolerance and the following specifications were approved by Technical Committee G:

	Old Specification	New Specification
Length (after truncation), in.	0.59 ± 0.01	0.59 ± 0.01
Base, in.	0.33 ± 0.005	0.33 ± 0.002
Angle of cone, deg.	30	30 ± 1
Diameter of truncated tip, in.	0.015 ± 0.003	0.015 ± 0.001
Material	Stainless or hardened steel	Hardened steel

[4] These tolerances were approved and appear in the revised Method D 217-47 T, 1947 Supplement to A.S.T.M. Standards Part III-A, p. 139. The revised Method as published in the 1947 Compilation of Standards on Petroleum Products and Lubricants are in error in that the revised tolerances were not shown on Fig. 4 showing the penetrometer cone.

TABLE III.—EFFECT OF TRUNCATION ON PENETRATION.

Grind No.	D-217 Tip	1	2	3	4	5	6	7	7a	7b	8	9	10	11	12
Tip diameter, in.	0.016	0.021	0.023	0.026	0.028	0.031	0.035	0.041	0.016[a]	0.016[a]	0.061	0.070	0.080	0.083	0.086
Penetration	32.0	30.0	30.0	27.5	26.9	26.0	24.0	21.5	21.2	20.9	11.4	6.5	1.7	1 0	1.0
	33.0	31.0	29.0	27.5	26.3	26.0	23.0	20.0	20.5	20.8	10.5	6.9	2.0	1.4	1.1
	33.0	30.0	29.0	28.0	27.3	25.3	24.0	21.1	20.6	21.5	10.5	6.7	2.0	1.0	1.0
	....	....	....	....	....	....	....	....	21.0	20.5	11.4	....	....	....	....
	....	....	....	....	....	....	....	....	20.5	....	....	....	....	....	....
Average	32.7	30.3	29.7	27.7	26.9	25.8	23.7	20.9	20.9	20.9	11.0	6.7	1 9	1.1	1.0
Truncation, mm./10.	7.7	10.1	11.0	12.5	13.4	14.9	16.8	19.6	19.6	19.6	29.2	33.5	38.3	39.7	40.9
Penetration plus truncation	40.4	40.4	40.7	40.2	40.3	40.7	40.5	40.5	40.5	40.5	40.2	40.2	40.2	40.8	41.9

[a] Repointed from 0.041 to 0.016. Truncation calculated using 0.041 (see Fig. 2).

Universal Plastics Testing Machine[1]

By G. S. Burr,[2] W. J. Gailus,[3] J. O. Silvey,[4] S. Yurenka,[5] and A. G. H. Dietz[6]

THE specialized requirements of the program of research into the mechanical properties of plastics materials sponsored at the Institute by the Plastics Materials Manufacturers Association—M.I.T. called for a testing machine embodying specialized characteristics. The large range of elastic and plastic properties of plastics materials and their sensitivity to time rates as well as to ambient atmospheric conditions made it necessary to develop testing equipment having unusual speeds, travel, and controls. The principal requirements set up for the machine finally designed were the following:

Capacity, 30,000 lb.
Rates of crosshead motion, 0.005 to 30 in. per min., in continuously variable increments.
Crosshead motion, 18 in.
Minimum inertia in the weighing and recording mechanism.
Positive control over crosshead motion in either direction with fastest possible reversal in direction.
Reversal of load on specimen without backlash when passing through zero, with grips capable of applying loads in tension and compression continuously on the same specimen.
Controls for:
(*a*) Constant rate of crosshead motion.
(*b*) Constant rate of load application.
(*c*) Constant rate of strain.
For possible future consideration: constant rate of stress. Size sufficient to allow the incorporation of temperature-control boxes.

Description of Machine

A brief description of the machine (Fig. 1) and its controls follows:

In view of the special requirements imposed upon this machine, it was necessary to design it with some unusual specifications in mind. The load weighing system should have a relatively high speed of response, in other words, low inertia; it should be capable of recording an extremely wide range of full-scale loads, from a few pounds to 30,000 lb., and should suffer negligible deflection under the action of the load. These requirements were met with a weighbar design utilizing bonded-wire strain gages and a sensitive amplifying and recording system. Inasmuch as it was also desired to measure creep and relaxation properties, the load recording system needed to have good stability over reasonable lengths of time.

These requirements dictated the use of a servo-mechanism type of control, operating through electrical, mechanical, and hydraulic circuits to move a double-ended hydraulic piston.

A simplified block diagram of the system is shown in Fig. 2, illustrating the manner in which the necessary flexibility of operation is achieved by feeding the desired signals into either the controlling servo or the recorder. Because the chart of the recorder is moving at a constant rate, the time axis on the chart represents the particular function which is under the control of the servo network. Thus, load can be recorded against a constant rate of strain or jaw separation; sample extension or jaw separation can be recorded against a constant rate of load, and so on, in any desired combination.

Inasmuch as it is very often desired to use the movement of the moving crosshead as a measure of deformation, particularly in com-

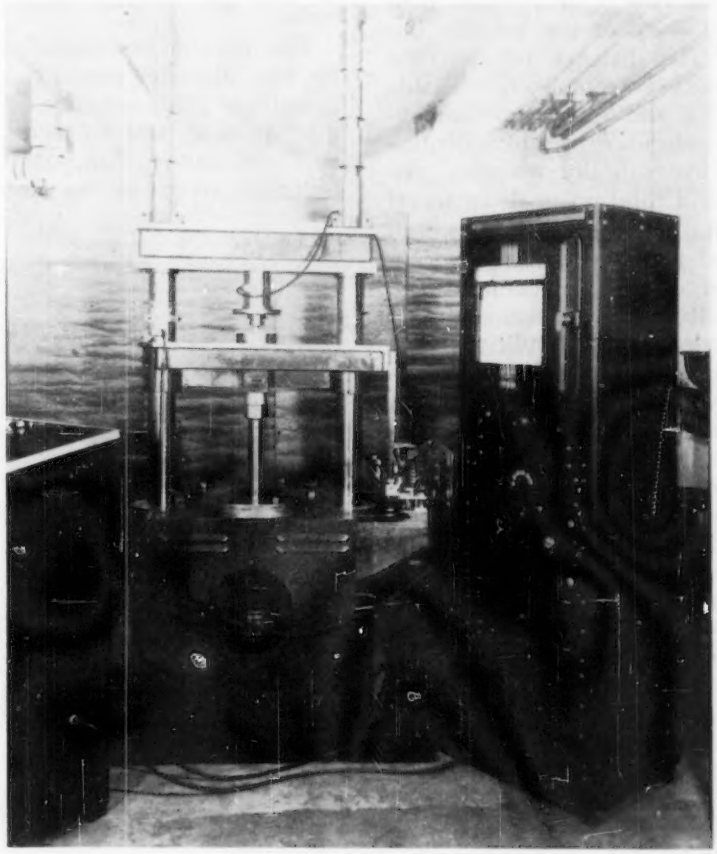

Fig. 1.—Universal Plastics Testing Machine.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at the Fiftieth Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 16–20, 1947.

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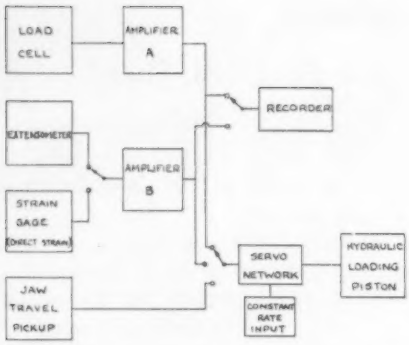

Fig. 2.—Block Diagram of Testing Machine System Showing Relationship of Hydraulic System, Servo Controls, Weighing System, and Recorder.

pression tests, the machine was designed so as to reduce deflection of the structural members and the crossheads to a minimum when under full load.

Body:

The body of the machine shown in Fig. 1 is designed to be light and trim but sturdy, affording the flexibility required for the plastics test program. With proper jigs and fixtures it can be used for tension, compression, bending, shear, some types of fatigue tests, and high velocity creep or low velocity impact. The distance between the crossheads is completely variable between 6 and 53 in. and the movable crosshead, driven by a double-ended hydraulically operated piston, has a total up or down travel of 18 in. The basic frame has been designed to deflect not more than 0.002 in. under a maximum load of 30,000 lb. This deflection occurs only under extreme conditions, that is, when the maximum load is applied with the columns in tension and the upper crosshead at the uppermost position. The deflections under ordinary conditions are less. Stresses set up in the frame by the 30,000-lb. maximum load are relatively small.

Welded construction is utilized throughout the machine to achieve minimum weight with maximum rigidity, especially in the moving and fixed crossheads. Welded ribs and box sections give a large strength-to-weight ratio to these parts in addition to making their construction possible from standard rolled plates, bars, and tubes.

For accurate leveling, the machine is supported at three points by a welded rectangular "picture" frame made of 4 by 4 by $\frac{1}{2}$-in. angles and channels. The "picture frame" itself rests on four shock mounts secured to the foundation with four $\frac{1}{2}$-in. studs. Because the height of the machine exceeds the floor-to-ceiling distance within the laboratory assigned to the project, the frame and lower half of the base of the machine are contained in a shallow pit. This brings the normal working space within the machine to a convenient level for the operator.

A Hanna H.P. 16 double-ended hydraulic cylinder drives the movable crosshead by means of a $2\frac{1}{2}$-in. diameter piston rod. The cylinder is accurately scrape-fitted and is secured to the machine by eight 1-in. bolts in such a way that it may be disassembled for repairs or inspection if necessary.

The upper end of the piston rod is threaded into the lower, or movable crosshead. At the center of the upper surface of this crosshead a $1\frac{1}{2}$-in. 12 NC thread is incorporated to provide a means for the attachment of various jigs and fixtures.

The movable crosshead is guided by 4-in. diameter precision ground cylindrical guide columns. To reduce friction, and to increase accuracy of motion, 7-in. long bronze bushings serve as the crosshead guiding surfaces. The guide columns provide the solution to the problem of correct alignment and straight travel of the crossheads. The straightness of the columns (as guaranteed by the manufacturer) is within 0.002 in. in 9 ft. The columns are parallel to within the same tolerance. Six circumferential rectangular grooves in the upper part of the columns are provided to fix the upper crosshead at different levels. A split ring and double-wedge arrangement is employed to lock the upper crosshead rigidly to the columns, permitting no detectable movement in either direction under all loading conditions. The lower ends of the columns are secured to the base of the machine which also contains the cylinder. The principal components of the base are two 3-ft. long sections of 8-in. extra strong pipe reinforced by several $\frac{3}{4}$-in. stiffeners and sandwiched between two $1\frac{1}{2}$-in. thick steel plates.

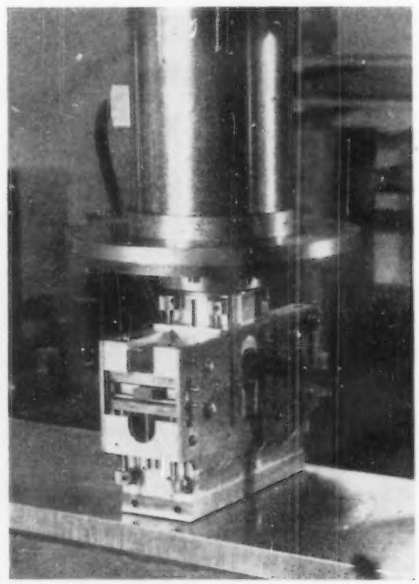

Fig. 3.—General View of Load Cell Attached to Upper Crosshead of Machine.

Load Indicator:

Attachable to either crosshead is the load indicating device, or load cell. It consists essentially of a special weighbar to which is bonded a resistance wire strain gage. Axial strains in the bar are measured and, being proportional to the load, are calibrated in pounds. The first cell built was designed for an operating range up to 5000 lb. and is typical in its details of the load cells to be employed for other ranges (see Figs. 3 and 4). It has five main components: a diaphragm, flange, tube, weighbar, and attaching bolt. All of the parts with the exception of the weighbar and diaphragm are made of mild steel. The weighbar

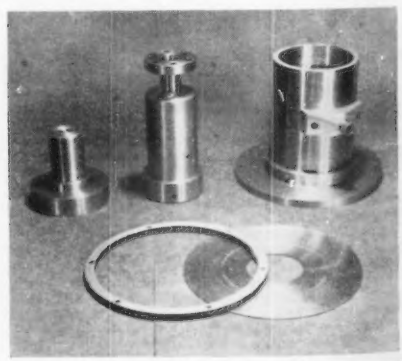

Fig. 4.—Disassembled View of Load Cell Showing Diaphragm, Flange, Tube, and Weighbar.

consists of a cylinder of No. 4140 nickel-alloy steel (in a hardened and drawn condition—yield point of about 110,000 psi.) machined and ground at one end to form a "weighing tube" with a mean diameter of 0.860 in. and a wall thickness of 0.030 in. The other end is threaded for testing grip attachment.

The weighbar is designed to have a maximum deflection of 0.002 in. under the 5000-lb. load. This corresponds to a stress in the weighing tube of about 60,000 psi. (tension or compression).

The steel diaphragm 0.0625 in. thick (designed to take up just 1 per cent of the axial load throughout the range of the load cell) is provided to prevent nonaxial loading of the weighing tube. Another of its important functions is to prevent torque from being transmitted to the weighing tube in attaching a testing grip to the load cell.

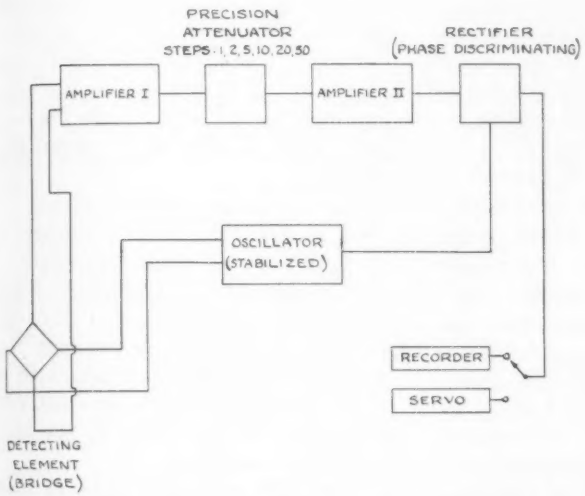

Fig. 5.—Block Diagram of Load and Extension Recording Circuits.

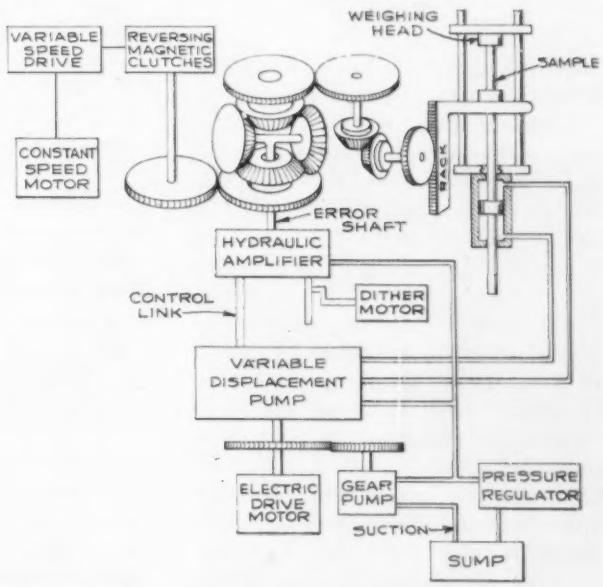

Fig. 6.—Diagram of Control System for Constant Rate of Crosshead Motion.

Load and Extension Recording Circuits:

The bonded wire strain gage is the principal element in the load cells and is one of the principal methods of detecting direct strain and small extensions. Therefore, the amplifying circuits were designed primarily to be used with this device, but are adaptable to other types of detecting elements that may be necessary in the development of adequate extensometers.

The circuit, shown in block form in Fig. 5, is based on the familiar a-c. Bridge principle, with certain refinements to make it suitable for the present application. The load cells are designed to cover a 50 to 1 full-scale range, and the minimum full-scale strain that is to be amplified is of the order of 30 microinches per inch. This requires large amplification and special care to eliminate the extraneous noise signals that appear in low level circuits. A special rectifier circuit was developed to provide an output that was a true measure of the resistance unbalance alone of the bridge, excluding capacity effects and stray hum pickup. Because the recorder operates on the deflection principle, rather than null balance, special care was necessary to insure that oscillation output be constant in spite of line voltage variations and other disturbances.

A precision attenuator was incorporated in the load amplifier to provide a means of varying the full-scale range of the recorder in the following discrete steps: 1, 2, 5, 10, 20, and 50 lb. These values are multiplied by a factor depending on the range of the particular load cell in use. In this manner, each cell needs to be calibrated only at the lowest value in its range, usually by dead weights, and the calibration can then be considered effective over its entire 50:1 range.

The recorder used is a high-speed ink-recording Leeds & Northrup Speedomax, with a specially built chart drive to provide chart speeds ranging from 2 to 50 in. per minute. The recorder will sweep a full-scale deflection in about 1 second, and will faithfully reproduce smaller deflections in proportionally less time. The chart width is 10 in. By means of zeroing controls on the amplifier it is possible to position the pen at center-scale or at any other convenient point in order to measure loads in either direction.

A separate circuit provides a small pip, or disturbance, on the record whenever the movement of the pulling jaw is stopped or started. This facilitates the interpretation of data for creep or relaxation studies. An overload circuit operates to stop the machine whenever the load exceeds a safe preset value, thus acting to prevent damage to the load cell.

Servo Controls:

The controller design was complicated because of the many modes of operation required, the relatively large ranges through which the rates and the magnitude of load were required to be varied, and because of the accuracy with which the rates of load, crosshead motion, and strain were to be controlled. To accomplish all objectives, it was decided to control the movable crosshead by means of a servomechanism. The mechanics of changing from one mode of opera-

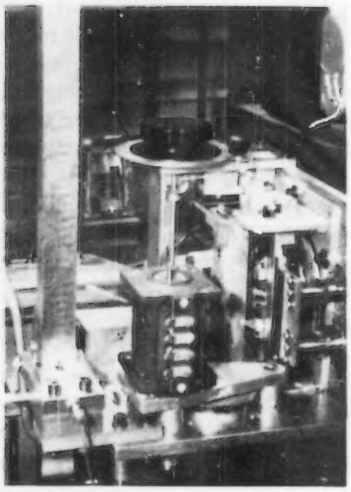

Fig. 7.—Detail of Servo System Showing Rack Attached to Movable Crosshead, Ball and Disk, Differential Cage, and Input Motor.

tion to another obviously had to be kept as simple as possible.

Constant Rate of Crosshead Motion.—The control system for constant rate of crosshead motion is shown schematically in Fig. 6. The servomotor is the hydraulic piston of the testing machine. This piston is controlled by means of a variable-displacement hydraulic pump. The pump stroke is controlled by means of a hydraulic amplifier consisting of a pilot valve, a control piston to control the pump stroke, and feedback linkages to make the control piston motion proportional to pilot valve motion. The sleeve in which the pilot valve moves is constantly dithered by means of an eccentric driven by a small auxiliary electric motor to keep friction between the pilot valve and sleeve at a minimum. Oil under pressure to supply the control piston is provided by a small gear pump which is driven by the same electric motor that drives the variable displacement pump. This gear pump also makes up any leakage that may occur in the variable displacement pump and the large piston of the testing machine. Control pressure is maintained approximately constant by means of a small ball-spring type regulator which returns all excess oil to the sump.

In constant rate of crosshead motion the desired input motion is imparted to one side of a mechanical differential. The other side of the differential is driven by a rack fastened to the crosshead of the testing machine. The differential cage is connected through gears and linkages to the pilot valve. The directions of motion are such that if the position of the crosshead does not correspond to the position indicated by the input, the hydraulic amplifier will displace the pump, and the crosshead will move in the proper direction to reduce the difference between required and actual crosshead position to zero. Hence, to produce constant rate of crosshead motion, it is only necessary to rotate the input gear of the differential at a constant speed. This is accomplished by driving the input gear by means of a continuously variable-speed drive of the ball-disk integrator type and a small constant-speed electric motor. Various speed ranges are obtained by means of change gears. A pair of magnetic clutches is used to obtain quick reversal of motion (see Fig. 7).

An auxiliary device is located in the hydraulic amplifier which prevents a positional lag which would otherwise occur when the crosshead is moving at a constant rate.

Constant Rate of Load.—The system used for load control is shown schematically in Fig. 8. To understand its operation, let us first ignore the presence of the derivative network and assume that amplifier No. 2 is connected directly to amplifier No. 3. In this form of control the controlling quantity is load rather than crosshead position. (In Fig. 8, the circuit from vacuum tube amplifier No. 1 runs to the load cell.) Consequently, the amplified electrical signal from the load cell is compared with the input signal. The input signal is obtained from a potentiometer, and the difference between input and output signals is obtained by connecting them in series with the polarities reversed. The difference, or error, voltage is amplified by amplifier No. 2 and amplifier No. 3 until it is of sufficient power to operate the electric control motor. This control motor is geared to the input gear of the differential. The other gears of the differential are meshed with the same gears as they were in constant rate of crosshead motion operation. The connections between the hydraulic amplifier, hydraulic pump, main piston, and feedback rack are exactly as they were for constant rate of motion. Consequently, the operation of the system is as follows: If the output load is different from that called for by the input signal, an error signal enters amplifier No. 2, passes to amplifier No. 3, and results in rotation of the electric control motor. This rotation changes the input to the differential, causing motion of the pilot valve, and hence motion of the main piston. A change of piston position, however, alters the load applied to the sample, thus changing the output of amplifier No. 1 until the output signal is equal to the input signal.

The electrical mixing circuit as well as the derivative network is used to produce greater stability of the system by introducing some derivative or "anticipation" into the control circuit. This enables the machine to test materials with a large range of properties without adjusting the constants of the vacuum-tube amplifiers.

Constant rate of change of load can be applied to the sample by rotating the shaft of the linear input potentiometer at a constant rate of change.

Constant Rate of Strain.—If the circuit in Fig. 8 is run from amplifier

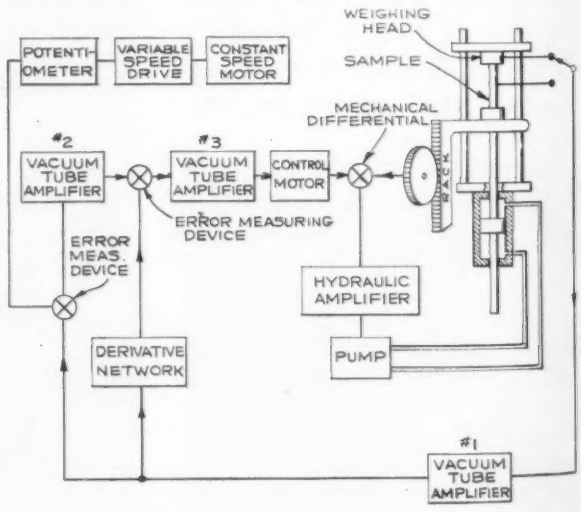

Fig. 8.—Diagram of Control System for Constant Rate of Load (Adaptable to Constant Rate of Strain).

No. 1 to the extensometer on the sample and the motion of the extensometer is converted into a change in voltage (by change in resistance, change in inductance, etc.), the servo controls employed for constant rate of load can be employed for constant rate of strain. The only difference in the operation of the servo controls is that the signal comes from an extensometer attached to the specimen instead of from the load cell. The operation of the various amplifiers and the rotation of the linear input potentiometer are unchanged.

Advantages of these systems of control are: once the transients have died out they are quite accurate; once calibrated, the settings for particular rates do not change; forces and pressures controlled directly by the calibrated speed drives are quite low. One minor disadvantage of servo control systems is that because they are actuated by an error between the input and the controlled quantity, they cannot begin acting until after an error has been produced. Hence, when a sudden input or rate of input signal is applied, a certain amount of time is required before the error settles again to zero. However, this time interval can be reduced to a value of approximately 1 sec. in the case of this machine.

Tension-Compression Grips:

The versatility of a testing machine such as described above would be of little practical value without having a method of applying to it the now fairly standardized procedures employed in the testing field. Thus came about the development of a different type of specimen grip which is described in detail below.

A photograph of the grips is shown in Fig. 9. The grips are of the open front type, that is, a specimen may be inserted directly from the side—a very desirable feature as it insures correct alignment of the specimens with ease and rapidity, which is especially important when a large number of tests have to be run.

Each grip is freely suspended by means of a special yoke in such a way that the grip floats on a $\frac{3}{4}$-in. polished steel sphere, thus insuring automatic alignment of the grips in tension testing. The clearances provided within the grips allow vertical freedom within a solid angle of 10 deg. Although the lower grip is in an inverted position and does not bear upon the steel sphere when not in use, other spherical surfaces support the weight of the jaw and keep it in an upright position until the slack is taken up by the specimen.

The special feature of these grips comes in the fact that once aligned they may be locked in position and the specimen subjected to compression as well as tension up to the maximum design load, that is, 30,000 lb. Adjustable wedges are provided which can be opened to accommodate a specimen with a maximum width of $1\frac{1}{4}$ in. and a thickness up to $\frac{9}{16}$ in. In operation, a specimen is inserted between the wedges and clamped manually with any reasonable degree of force, after which the wedges continue to tighten on the specimen automatically, with a force proportional to the tension in the specimen. This force can be "locked" onto the specimen at any desired level so that the specimen may then be subjected to a compressive load. After the specimen is broken, the ends can be easily released by the same manual control which was used to secure it initially.

To insure positive gripping of specimens of different hardness, several sets of removable hardened face plates are provided with the wedges. These have graduated degrees of sharpness and tooth depth. Other than flat specimens can be accommodated by using specially formed face plates.

The satisfaction of the specification of a 30,000-lb. rated capacity for the grips and the inclusion of the special features desired resulted in grips weighing about 60 lb. each. However, the size of the grips is held to a minimum by such close packing of the component parts that the grips actually weigh about 90 per cent as much as a solid piece of steel having the same outside dimensions. The over-all height of each grip is 11 in. and is designed to obtain the maximum capacity of specimen length between the crossheads of the testing machine.

Acknowledgments:

The authors wish especially to acknowledge the assistance of Leon Marsh, consulting engineer, in the design of the body of the machine; G. S. Brown of the Massachusetts Institute of Technology Servo-mechanisms Laboratory for suggestions respecting the controls; L. J. Lipschutz for assistance in the design of the load cell; W. H. Campbell for assistance in the development and assembly of the various components; and A. C. Ruge in the development of the weighbar.

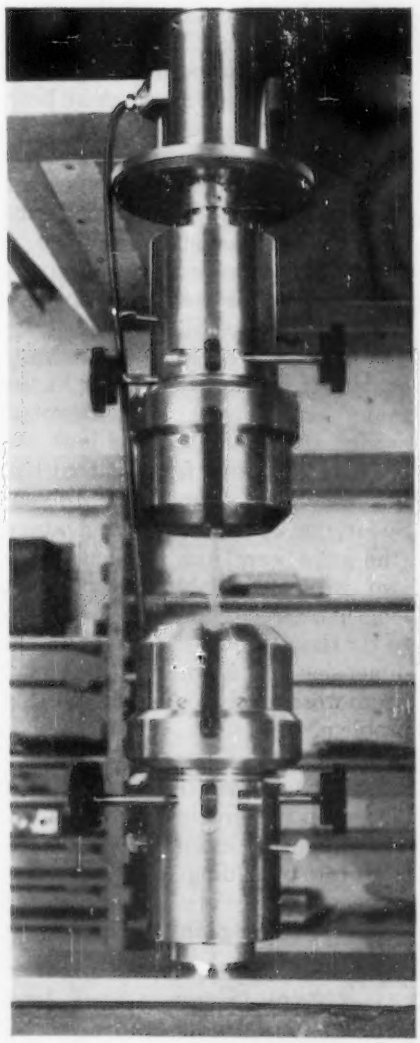

Fig. 9.—View of the Grips.

MR. E. M. REDSTREAKE.[1]—Is the load indicated on a dial?

MR. A. G. H. DIETZ (*author*).—The load is indicated on a moving paper chart to provide a pen and ink record of every test.

MR. CLARE L. MILTON, JR.[2]—What is the frequency of the oscillator in the load-measuring circuit?

MR. DIETZ.—The oscillator frequency is 400 cycles per second.

MR. L. N. PHILLIPS.[3]—One of the great virtues of this apparatus is the ability to go continuously from compression to tension without having to reset the grips or extensometers in any way. It should therefore be possible to get complete hysteresis diagrams. There are two possible sources of error here that I should like to query. First: Is there absolutely no backlash from the rack and pinion mechanism used to record the motion of the crosshead? Second: What shape of test specimen has been decided upon that gives correct readings in both tension and compression tests?

MR. DIETZ.—Backlash has not been evident. We were somewhat concerned about this, but performance has been satisfactory.

As for the proper type of specimen to use for tension and compression, we are still experimenting. The specimen will have to be short, evidently, to avoid buckling. At the same time stress concentrations around the fillets near the jaws are to be avoided and, frankly, that has not yet been completely solved. So far, our work is very rudimentary (the grips were just finished about two weeks ago) but a specimen length between jaws of about five to six times the least cross-sectional dimension has seemed satisfactory. More work needs to be done on this problem.

MR. LUCIUS GILMAN.[4]—I do not see why you have to have two servo devices in the circuits where you are operating, for example, at a constant rate of loading.

Since there are two counter voltages coming in at the same point, why can't the differential voltage which comes out be used to control the speed of the drive motor instead of having to feed it through the mechanical servo?

MR. DIETZ.—This could be done, but it would require that the hydraulic piston be replaced by an electric motor of the same power and that the power amplification of the mechanical servo (which is approximately from $\frac{1}{100}$ to 2 hp.) be obtained by electrical means. The use of the existing motor which drives the hydraulic pump is impossible because of undesirable characteristics as a control motor.

Having decided that the variable displacement pump-hydraulic piston combination would be the simplest system to use for constant rate of crosshead motion, the easiest way to obtain constant rate of load was by means of the two-servo system.

MR. J. R. STOVALL.[5]—I should like to ask two or three questions. Did you have any trouble when you used your rack and gear arrangement down to the low speed, which I think was 0.01 in. per min.? That is rather a low speed for using a rack and gear.

MR. DIETZ.—It does seem like a rather slow motion but it seems to be operating well. There is some spring loading to remove backlash, and the rack is accurately cut. As a matter of fact it has been used at speeds as low as 0.003 in. per min. with no detectable error using the same gear differential. It was checked against dial gages placed directly under the crosshead to check the motion of the dial gages against the motion recorded on the chart and there was no appreciable error. "Appreciable" needs definition. The requirement was that the system should operate with not more than 1 per cent error. The motion of the crosshead was within this requirement.

MR. STOVALL.—The second question is this: Judging from the diagrams, I believe the load indications were made by recording voltage output. Then you would depend on a linear constant gain amplifier? Is that correct?

MR. DIETZ.—Yes. The amplifier is a linear constant gain circuit.

MR. STOVALL.—Then the third question is this: Also from the diagram, I believe the ratio on the attenuator was 1 to 50.

MR. DIETZ.—That is correct.

MR. STOVALL.—And you use a single cell for that?

MR. DIETZ.—Yes.

MR. STOVALL.—The reason I ask is that, if you use a single 5000-lb. cell, you have a 50 to 1 ratio. Assuming that you have a 0.1 per cent sensitivity, that gives you a dynamic range for the strain gage of 50,000 to 1. Now were you able to work the strain gages at that dynamic range? That is quite a large range. I have never seen them used in that wide a range before.

MR. DIETZ.—Yes, we have used that load cell mostly so far on the 100-lb. range—that is to say, the 50 to 1 range. The cell has been checked a number of times against dead weights and also has been checked for the full 5000-lb. range against the Morehouse ring, and there has been not more than 1 per cent error in the record.

MR. H. M. QUACKENBOS, JR.[6]—I have three questions about this remarkable piece of equipment. One: Whereas the electrical system would be very quick to respond, would not the pump be rather slow? Two: On the 100-lb. range the maximum strain gage reading is 30 microinches per in. A precision of ±1 per cent therefore corresponds to only $\frac{1}{3}$ microinch. Could not a small temperature differential within the system cause thermal expansion greater than $\frac{1}{3}$ microinch and so invalidate the precision? Three: How often will recalibration be necessary to check the constancy of the electric strain gages and thus the constancy of the weighing system?

MR. DIETZ.—The pump is a Vickers Variable Displacement Pump, and the total motion of the control valve for full speed in one direction—full pressure in one direction and full pressure in the

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[2] Chief, Plastics Development Branch, Army Prosthetics Research Lab., Washington, D. C.
[3] British Commonwealth Scientific Office, Washington, D. C.
[4] Chief, Plastics Lab., Picatinny Arsenal, Dover, N. J.
[5] Electronics Department, Tinius Olsen Testing Machine Co., Philadelphia, Pa.
[6] Bakelite Corporation, Bloomfield, N. J.

other direction—is about $\frac{1}{8}$ in. It can be changed from full speed forward to full speed back in a fraction of a second.

There is a very small overrun which is unavoidable, but it is very small. It is less than the requirement of not more than 1 per cent error which was established for the system.

The possibility of temperature errors has been borne in mind. The system—the machine itself—is in an air-conditioned space in which the temperature and humidity conditions are kept reasonably constant. We try to maintain the A.S.T.M. standard conditions. The gages on the weighbar are within the heavy enclosing cell and the temperature within it probably undergoes a very small change. If there were marked temperature changes within the system, they might easily throw it off more than 1 per cent.

For the time being, we expect to calibrate frequently against a Morehouse ring or against dead weights until we find out more about the stability of the system.

The previous history of strain gages in other pieces of equipment in the Institute has been quite satisfactory, especially in air-conditioned space. The Textiles Laboratory has a history going back over perhaps two years. It has been found that when gages are baked onto the surface—not just put on with Duco or similar types of cements—and when they are also very carefully sealed against any moisture change by a heavy coating of wax, paraffin, or something of that nature, the gages have had a good history of stability.

It is recognized that stability is certainly something that must be watched, but we felt that in a piece of research equipment it was something that could be checked at rather frequent intervals.

Mr. Milton.—While there is little doubt that strain gages are capable of being employed over the 50,000 to 1 range that you have used, to take advantage of this range requires the measurement of voltages to fractions of a microvolt or balancing to a similar precision. Is that not correct?

Mr. Dietz.—That is correct.

Mr. Milton.—The difficulties in designing a recording apparatus of this precision are well known and Mr. Dietz and his colleagues deserve congratulation. The familiar method of eliminating the intrusive voltages (which must be considerably larger than your precision of measurement) by the use of a rapid reversing switch like that of the Wenner potentiometer would be most difficult of application to a recorder. Would you care to go into any detail as to how you took care of intrusives in the gages and a-c. amplifier which the block diagram indicated as the first stage of your apparatus?

Mr. Dietz.—It is true that stray hum pickup in the circuit can be several times the magnitude of the signal. It is kept to a minimum by very careful construction. The residual is isolated from the recorder by means of the phase discriminator circuit.

If we are going to operate at loads much less than 100 lb., we do not intend to use that 5000-lb. cell. A lighter load cell will be built, since we have no expectation that we will be able to go to much less than 100 lb. with a high degree of accuracy with this cell. We expect probably to have three cells: one for low ranges up to 500-lb. maximum, one for 5000-lb. maximum, and a third for the full capacity of the machine.

Mr. J. J. Lamb.[7]—You mentioned in several cases a variable rate. Do you mean that you can feed a signal in—such as a sine wave—to give you a variable rate of straining?

Mr. Dietz.—To a certain extent you could. For instance, suppose that in the rate of load mechanism instead of rotating the potentiometer at a constant rate it were rotated at a variable rate, such as one that would correspond to a sine wave. There is no reason why the machine should not respond to that type of input as well as a constant rate input.

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[7] Physicist, National Bureau of Standards, Washington, D. C.

Symposium on Insulating Oil

Introduction to Second Series

By L. B. Schofield[1]

The Symposium on Insulating Oil sponsored by Subcommittee IV on Liquid Insulation of A.S.T.M. Committee D-9 on Electrical Insulating Materials has been planned to be presented in a series of meetings sponsored by the committee. The first series was held in Atlantic City on October 16, 1946, and the following four papers were presented:

Steam-Emulsion Number as an Index of Transformer Oil Serviceability—M. D. Baker.
The Interfacial Tension Test and Its Significance in Appraising Performance of an Insulating Oil—G. W. Gerell.
Application of the Interfacial Tension Test in Grading Transformers Relative to Serviceability—E. F. Walsh.
Refresher on Statistical Analysis Applied to Two A.S.T.M. Oil Dielectric Strength Test Procedures—E. W. Greenfield.

The papers by Messrs. Baker, Gerell, and Walsh were printed in the May ASTM Bulletin, pages 90 to 100. The paper by Mr. Greenfeld is published in this issue.

This second series was presented June 17, 1947, in conjunction with the Fiftieth Annual Meeting of the Society in Atlantic City, N. J.

It has long been the consensus of the Subcommittee IV membership that both producers and consumers of electrical insulating oil are especially interested in any means of improving the life of insulating oil in electrical apparatus and the development of improved test procedures that will allow accurate appraisal of a new oil or an oil in service with reference to its continued serviceability.

This latest symposium was organized to bring together oil producers, apparatus manufacturers, utility engineers, exponents of special research and others to express their respective veiwpoints on the two subjects selected for treatment at this session. Two papers for discussion were presented by specialists on one subject dealing with the possible advantages in using oxidation inhibitors in insulating oil. Another paper was delivered to show the meaning of oil power factor data and accelerated aging tests in judging stability of an insulating oil. The fourth paper referred to the more practical application of power factor tests along with other observations as potential tools of the transformer maintenance engineer in his vigilant search for reliable methods of judging oil serviceability.

These discussions provided quite comprehensive treatments of these very live and at present somewhat controversial issues.

[1] Materials Engineer, Commonwealth Edison Co., Chicago, Ill.; Chairman of Symposium Committee Subcommittee IV of Committee D-9

Advantages of an Inhibited Transformer Oil

By T. E. Reamer[1] and R. G. Larsen[1]

Synopsis

The factors which lead to the deterioration of transformer oils in service are discussed. Numerous accelerated tests for measuring the stability of such oils are considered together with criteria of evaluation. One procedure developed by the authors is described in detail.

Increased oil life has been attained by the addition of an appropriate inhibitor to a suitably refined stock. Numerous data from laboratory and full-scale tests are presented which demonstrate that greatly improved stability can thus be achieved without the impairment of other properties essential for use in transformers.

The core and coils of many types of substation and distribution transformers are immersed in a petroleum oil which provides electrical insulation and carries heat away from the warm elements. The requirements of a transformer oil include good dielectric properties, low viscosity to facilitate heat transfer by convection, low pour point to avoid solidification at low temperatures, high flash and fire points to minimize danger of fire and explosion, and low volatility to reduce evaporation losses. The selection and refining of the proper oil fraction to meet these specifications is not too difficult, but maintaining the desirable properties in service is a troublesome problem.

Transformer oils are subjected to various environmental influences such as elevated temperatures, moisture, and atmospheric oxygen for long periods of time, and hence deterioration occurs. Thus, the insulating property of the oil (dielectric strength) decreases because of moisture and other suspended matter. There is accumulation of oxidation products such as acids which promote emulsification of water in the oil, sludges which impede adequate circulation and cooling by the oil, and peroxides which are detrimental to the strength of the fabric insulation on the windings. Clearly, then, the prevention or retardation of oxidation of transformer oils is a major maintenance problem. Records of a large utility company indicate that the oil in unprotected transformers requires renewing, on the average, every 5.6 yr.

Transformer manufacturers have sought to overcome the difficulty by supplying selected oils to the purchaser and by proper design of the transformer. Inert-gas blankets over the oil, conservators to prevent

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Chemist and Head, respectively, Lubricants Research Div., Shell Development Co., Emeryville, Calif.

direct contact of oil and air, adsorption of oil oxidation products by alumina, and other devices have been used to mitigate the results of oil oxidation. Such arrangements, although more or less effective, are generally used in the larger units while the small transformers remain unprotected. A recent survey (1)[2] indicated that sludging is a very serious problem in the older types of open breather transformers, particularly those operating at rated capacity.

Purpose of Inhibited Oils

There has been an increasing realization in many fields that great benefit can be obtained through inhibiting oxidation by chemical means. Turbine oils containing antioxidants and rust preventives have been very successful, and operating records are now available indicating their considerable advantages. Motor oils containing antioxidants, among other additives, are finding wide acceptance by the public; hydraulic oils and many other products have also been greatly improved. The same beneficial procedure has not been applied generally to transformer oils, although recent advances in the petroleum and electrical fields would seem to make this development inevitable.

The antioxidant added to dielectric oils should not impair essential properties, such as, solubility of water in the oil; color; acidity; copper-strip corrosion; pour and flash points; and electrical properties, such as dielectric strength, conductivity, and power factor.

True inhibitors, in contrast to metal passivators and retardants, delay the onset of normal oxidation of the oil without altering the final rate or type of oxidation following exhaustion of the additive. Furthermore, modern antioxidants are effective in moderately refined base oils and do not require the use of "over-refined" stocks such as English Grade "A" oils which are prone to rapid acid formation. In addition, with appropriately refined base oils the oxidation rate after the eventual exhaustion of the inhibitor is comparable to that of current uninhibited oils.

Excess heat, resulting from overloading or sludge formation, is detrimental to both the oil and the transformer. However, a properly inhibited oil giving little or no sludge not only should increase the life of the transformer but also should itself have as great a service life and thus should not require renewal.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

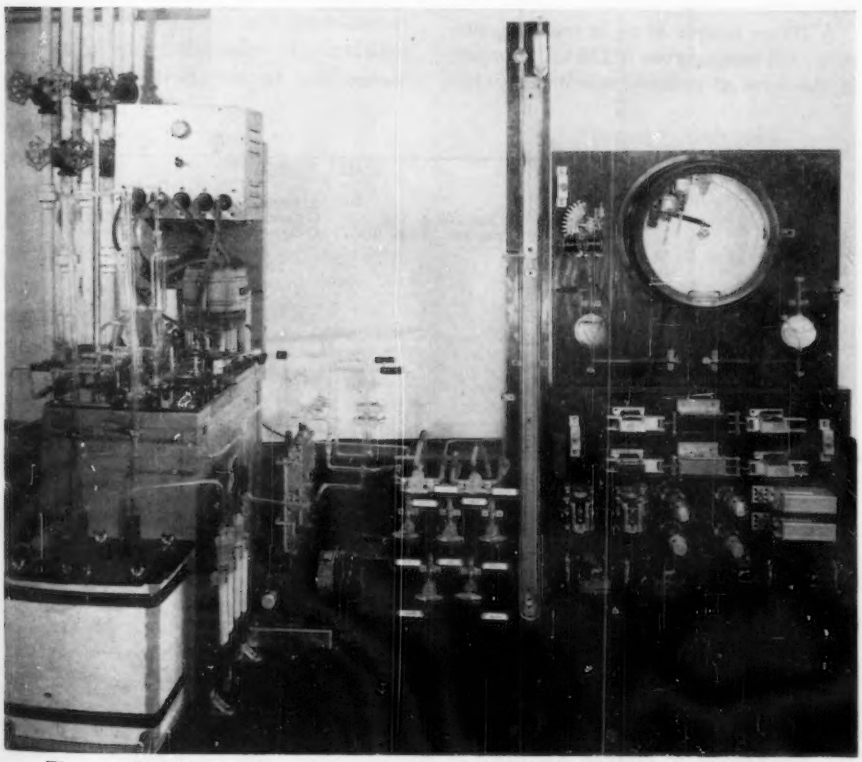

Fig. 1.—Shell Development Accelerated Transformer Oil Oxidation Apparatus.

Fig. 2.—Glass Oxidation Cell Used in Automatic Oxidation Apparatus.

Accelerated Testing of Transformer Oils

A requisite in the development of any improved product is obviously the devising of a means of evaluating the benefits obtained by varying its composition. Consequently, an accelerated test was devised which permits evaluation of inhibited as well as conventional oils.

Many accelerated transformer oil laboratory tests have been proposed, some of which have been recently reviewed (2, 3). A shortcoming of most of the tests is that they are conducted for a fixed period of time, during which interval some oils oxidize much more than others and the extent of oxidation does not usually correspond to the degree of deterioration found in service. Time is thus the factor which limits the test period and not the extent of oxidation. Few tests give a continuous indication of the oxidation rate of the oil. Some oils oxidize rapidly at first but slow

TABLE I.—PROPERTIES OF A TRANSFORMER OIL BEFORE AND AFTER THE ADDITION OF AN ANTIOXIDANT.

Properties	Base Oil	Base Oil Plus Additive
Specific gravity, 20/4 C...	0.8665	0.8665
Acid neutralization no., mg. KOH per g.....	0.0(0)	0.0(0)
Viscosity, Saybolt Seconds Universal at 100 F.....	60.4	60.4
Pour point, deg. Fahr.....	Less than −70	Less than −70
Flash point, COC, deg. Fahr.....	310	310
Color, union.....	1−	1−
Dielectric strength, kv. (A.S.T.M. Method D 149)[a]	33	33
Mineral acids (A.S.T.M. Method D 117)[a]	None	None
Free and corrosive sulfur (A.S.T.M. Method D 117)[a]	None	None
B.S.I. sludge test, per cent sludge.....	0.3	0.0
650 ml. O_2 absorption time, hr. (Shell Development Accelerated Oxidation).....	6	155
Interfacial tension, 25 C., dynes per cm.....	48	50

[a] 1946 Book of A.S.T.M. Standards, Part III-B.

down at an undetermined point during the test, while other oils, particularly inhibited ones, remain unchanged for relatively long periods before oxidation occurs. With many tests, oils of these two types cannot be differentiated.

Thus an accelerated method should continuously measure the rate of oxidation and should be terminated at a predetermined degree of deterioration corresponding to that found under service conditions. Of course no laboratory procedure can be relied upon to predict accurately the life of an oil under the conditions of service in a transformer when extrapolation may be projected as long as 25 years; however, such tests are useful as a research tool in determining the relative stabilities of oils. A much better but more expensive and cumbersome solution is the use of full-scale transformers operating at above-normal oil temperatures.

Shell Development Accelerated Transformer-Oil Test:

A procedure was devised which measures the oxidation rate and is terminated at a fixed degree of deterioration. Factors considered in developing the test included the nature and amount of catalyst, temperature, oxygen concentration, and presence of water and insulating varnishes. The conditions finally selected make the test particularly suited for evaluation of oxidation-resistant inhibited oils.

The apparatus is patterned after Dornte (4) and is similar to that used for the evaluation of lubricating oils in these laboratories (5). Oxygen gas at atmospheric pressure is recycled by a Sylphon bellows pump through the heated oil in a glass reaction vessel containing metal catalysts (Fig. 1). Volatile oxidation products are condensed in a cold trap while the remaining water vapor and carbon dioxide are removed by adsorbents. Since oils are oxidized to a relatively low degree, the accumulation of inert gases in the system is not sufficient to impair the validity of oxygen pressure decrease as a measurement of the rate of oxidation.

The oxidation cell containing the oil, Fig. 2, is made of glass and fitted with a sintered glass thimble at the end of the oxygen inlet tube which disperses the gas upawrd into fine bubbles, thus providing a large gas-oil interface and adequate agitation. The oxygen circulation rate is kept at 200 ml. per minute, although the rate is not critical as long as it is well above that of absorption.

Operation of the automatic oxygen-measuring system is as follows: When the confining liquid in the 100-ml. metering bulb reaches the upper electrode sealed in the glass, a system of relays and solenoids actuates a slide valve connected to a low-pressure oxygen supply. The liquid in the metering bulb (ethylene glycol saturated with potassium chloride) is consequently forced downward until the lower electrode is exposed. The relay and valve system then automatically connect the dispensing bulb to the absorption system. A mark is made upon the rotating chart of the chronograph each time the cycle is repeated, thus relating time to oxygen absorption.

A 100-g. sample of oil is used for each run. Oil temperature is 120 C. Copper, in the form of polished wire helices (150 sq. cm. per 100 g. of oil) and sandblasted lamination iron (37.5 sq. cm. per 100 g. of oil) are taken as catalyst. The reaction is continued until the sample has absorbed at least 650 ml. of oxygen, which corresponds to an acid neutralization number of approximately 1. Acidity, saponification number, color, and sludge values are determined. The absorption data are plotted as volume (N.T.P.) of oxygen absorbed against time (in hours). Reproducibility is about 5 per cent.

Test results are reported as induction period (hours) and as the time required to absorb 650 ml. of oxygen per 100 g. of oil. Induction periods, usually observed only in oils containing additives, represent the active life of the antioxidant under the test conditions.

Comparison of an Inhibited Transformer Oil with Uninhibited Oils

The addition of relatively small amounts of a selected antioxidant to a properly prepared base oil does not alter the results of any of the usual specification tests except the oxidation stability. A comparison of the properties of an inhibited oil before and after the addition of an antioxidant is given in Table I and demonstrates that the results of such responsive tests as acidity, corrosive sulfur, interfacial tension and dielectric strength are not affected. However, oxidation stability is increased several fold. It will be noted that the base oil without antioxidant is classified as grade B according to the British Standards

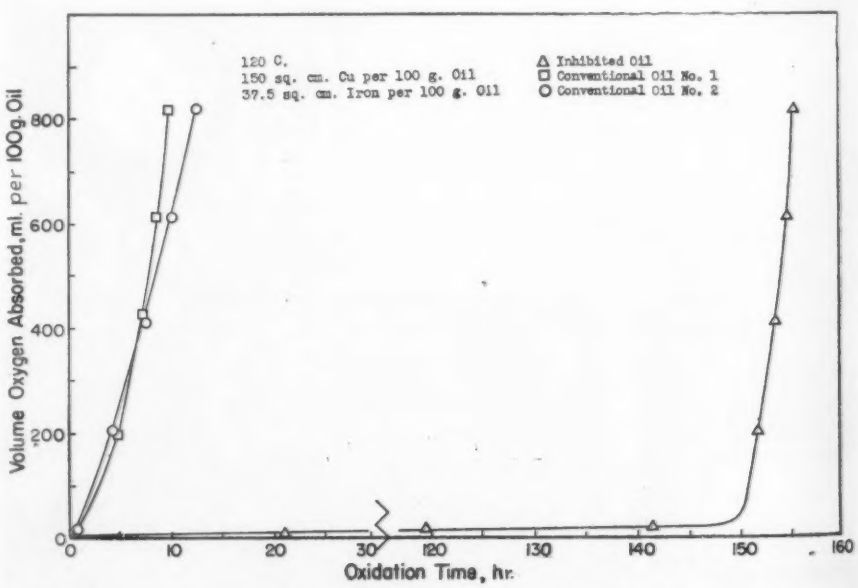

Fig. 3.—Volume of Oxygen Absorbed versus Oxidation Time for Inhibited and Conventional Transformer Oils.

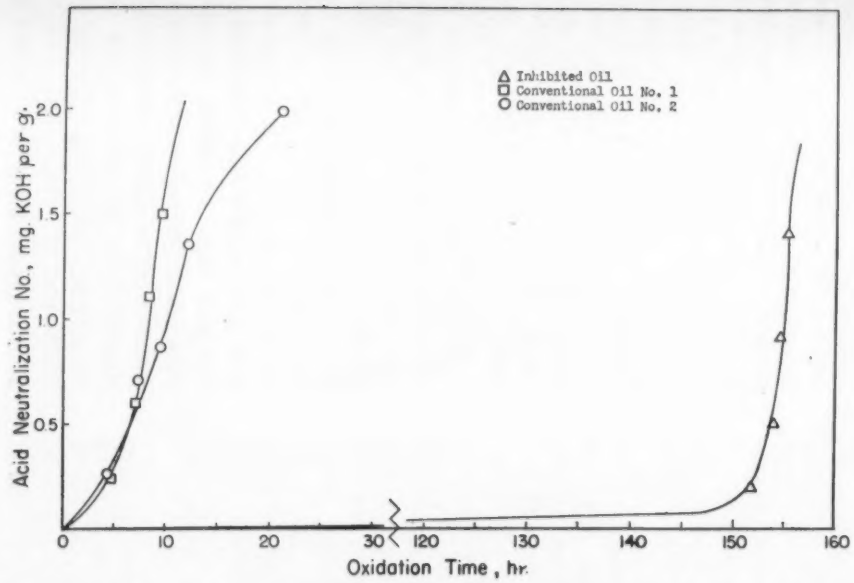

Fig. 4.—Acid Neutralization Number versus Oxidation Time for Inhibited and Conventional Transformer Oils.

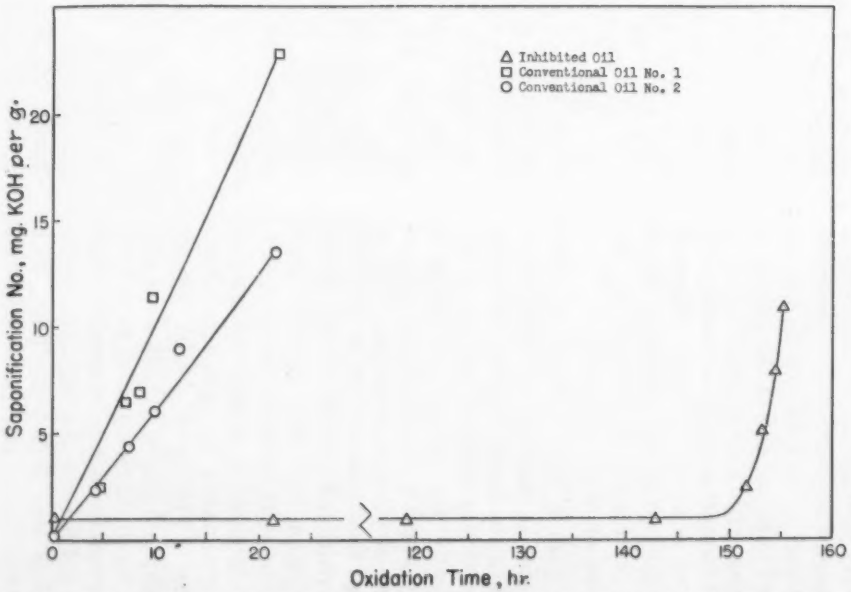

Fig. 5.—Saponification Number versus Oxidation Time for Inhibited and Conventional Transformer Oils.

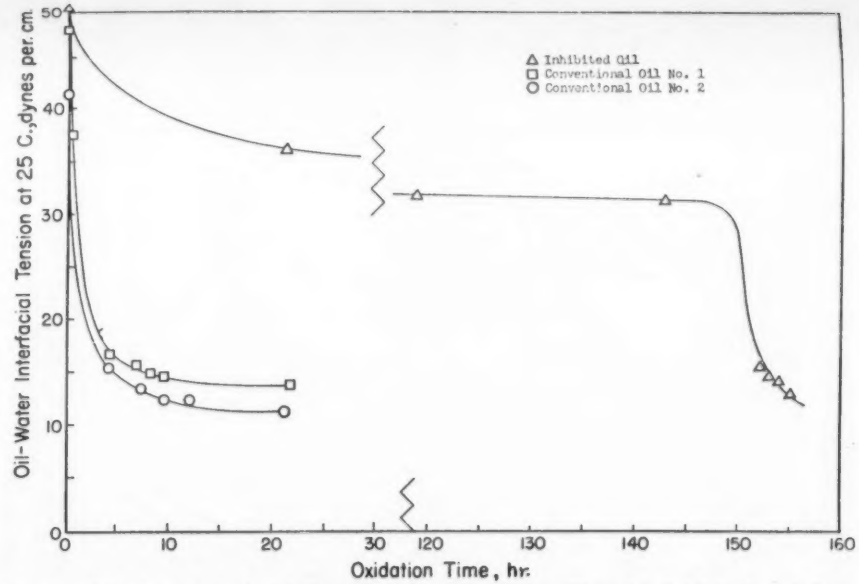
Inhibited Oil
Conventional Oil No. 1
Conventional Oil No. 2
Oil-Water Interfacial Tension at 25 C., dynes per cm.
Oxidation Time, hr.

Fig. 6.—Oil-Water Interfacial Tension versus Oxidation Time for Inhibited and Conventional Transformer Oils.

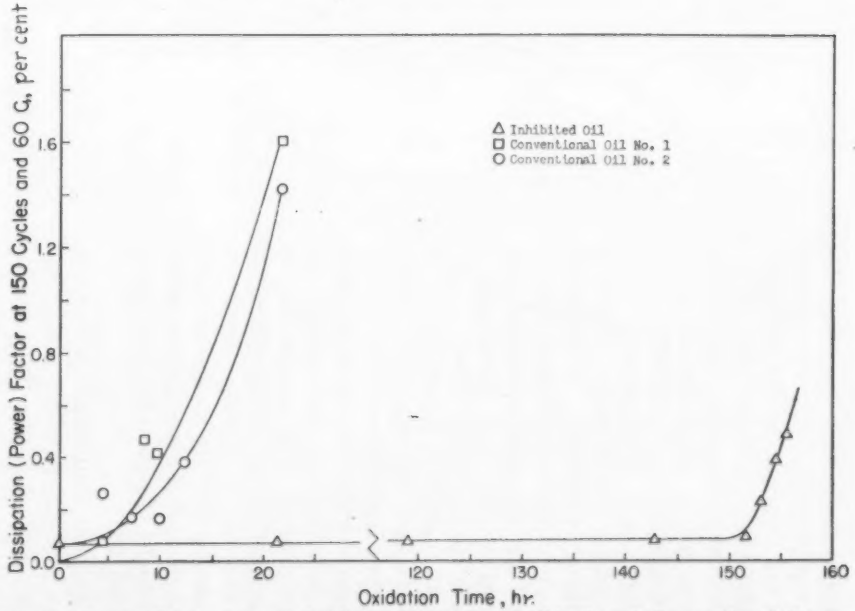
Inhibited Oil
Conventional Oil No. 1
Conventional Oil No. 2
Dissipation (Power) Factor at 150 Cycles and 60 C, per cent
Oxidation Time, hr.

Fig. 7.—Power Factor versus Oxidation Time for Inhibited and Conventional Transformer Oils.

Institute sludge test; and that this oil, compounded with antioxidant, does not form any sludge under the conditions of the B.S.I. test.

To demonstrate that there is little change in the properties of an inhibited oil during the life of the antioxidant, tests were made on three oils which had been subjected to oxidizing conditions. Comparison of an inhibited oil with two conventional oils was made under the conditions of the Shell Development Accelerated Oxidation Test, samples being obtained at various predetermined degrees of oxidation. Oxidation time is plotted *versus* volume of oxygen absorbed for the three oils in Fig. 3. Although the inhibited oil absorbs very little oxygen during the induction period, the other two at once oxidize rapidly. However, the absorption rate for the inhibited oil at the end of the induction period is virtually the same as for the uninhibited oils.

The acid neutralization number, saponification number, color, and sludge content of the three oils are given in Table II and Figs. 4 and 5. It is noteworthy that, whereas acidity and saponification values of the conventional oils increased rapidly throughout, development of appreciable acidity and saponifiable material in the inhibited oil was delayed until the end of the induction period, with the subsequent rate of acid formation closely following that of the conventional oils. Increase in color and sludge content of all the oils corresponded closely to the formation of acids.

Figure 6 is a plot of oil-water interfacial tension as determined with a du Nouy tensiometer using appropriate connections (6). Apparently the interfacial tension is very sensitive to small amounts of polar oxidation products, since a drop was observed with the two conventional oils after only 20 ml. of oxygen had been absorbed (acid Nos. of 0.04 to 0.05); further oxidation resulted in a rapid lowering to approximately 15 dynes per centimeter. The very slight oxygen absorption of the inhibited oil during the induction period gave some decrease in interfacial tension which did not become marked until the inhibitor was depleted. Thus, it is justified to use interfacial tension as a means of following the deterioration of oils in service during the initial stage of oxidation; however, after oxidation products have reached a limiting concentration (as indicated by an acid number of about 0.25), interfacial tension values become quite insensitive to further deterioration.

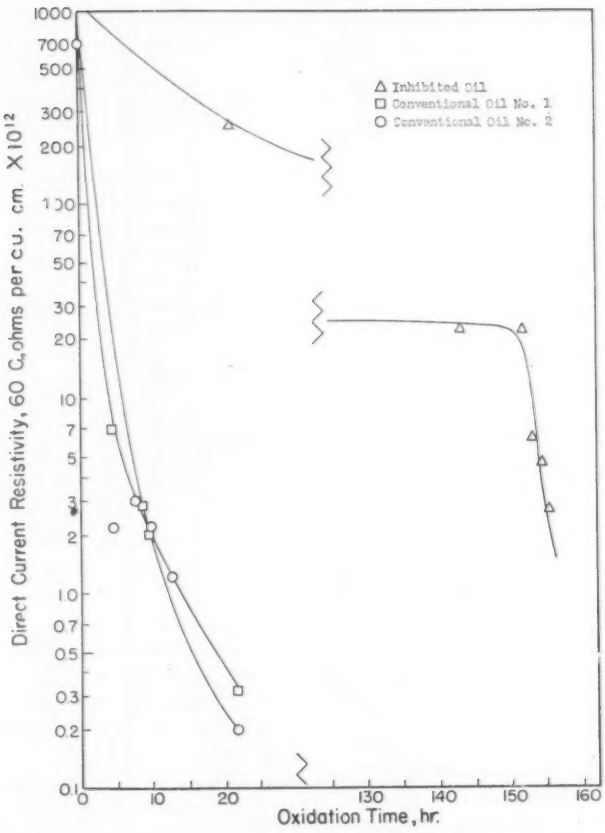

Fig. 8.—Direct-Current Resistivity versus Oxidation Time for Inhibited and Conventional Transformer Oils.

Power factor measurements of the oils, Fig. 7, show that dielectric losses do not become objectionably large until oxidation is well advanced. No increase in power factor could be observed during the induction period of the inhibited oil, although the error in measurement of the low values was unavoidably large with the available equipment.

Direct-current resistivity measurements, Fig. 8 and Table II, indicate that these values decrease rapidly as oxidation proceeds; however, the value for the inhibited oil decreases only slightly during the induction period.

Peroxides are one of several types of oxidation products present in deteriorated oils. As first reported by Stager (7), peroxides may react with cellulose to form friable oxycellulose. Several of the component parts of a transformer—notably cotton insulation on the windings, spacers, and thread used to tie various units—contain cellulose. If the cellulose becomes weakened by immersion in oxidized oil, sudden jarring of the transformer may result in breakdown. To illustrate the weakening influence on cotton, two oils were subjected to an oxidizing environment. A conventional oil, after aging, had an acid neutralization number of 1.4 mg. KOH per g. and a peroxide number of 5.3 milliequivalents per liter, whereas an inhibited oil aged in precisely the same manner was free of acids and peroxides. Pieces of pre-dried cotton thread were then immersed in the oils at 100 C. Tensile strength measurements after 6 days indicated that the thread from the oxidized oil dropped from an initial breaking strength of 3400 g. down to 1500 g., whereas the breaking strength of the thread from the inhibited oil decreased only to 3200 g. Similar experiments in which peroxides of known composition were added to

TABLE II.—PROPERTIES OF AN INHIBITED OIL AND TWO CONVENTIONAL OILS AT VARIOUS STAGES OF OXIDATION.

Oxidation at 120 C. with Copper and Iron Catalysts.

Transformer Oil	Accelerated Oxidation Data		Acid Neutralization Number, mg. KOH per g.	Saponification Number,[a] mg. KOH per g.	Color (Union)	Sludge (A.S.T.M. Methods D[b] 670–42 T), per cent	Interfacial Tension, Oil *versus* Water, dynes per cm. at 25 C.	Power Factor[c] 60 C., 150 Cycles, per cent	D-c. Resistivity, 60 C., ohms per cu. cm. $\times 10^{12}$
	Volume Oxygen Absorbed, ml. per 100 g.	Absorption Time, hr.							
Inhibited oil	0	0	0.0(0)	0.6(4)	<1	0.0(0)	50.4	0.08	>1000
	~10	21.1	0.0(0)	0.6(6)	1½–	0.0(0)	36.2	0.08	260
	~14	77.7	0.0(0)	.....	2–	0.0(0)	35.2	0.08	41
	~16	94.0	0.0(0)	.....	2–	0.0(0)	32.5	0.08	232
	~18	118.9	0.0(1)	0.6(5)	2–	0.0(0)	31.8	0.08	23
	~20	142.8	0.0(1)	0.7(7)	2–	0.0(0)	31.5	0.08	15
	206	151.6	0.2(0)	2.(4)	2	0.0(1)	15.6	0.10	23
	412	153.1	0.4(9)	5.(0)	2	0.0(0)	14.5	0.23	6.1
	618	154.5	0.9(0)	7.(8)	2½	0.0(1)	14.1	0.39	4.7
	824	155.2	1.4(1)	10.(8)	3–	0.0(0)	13.0	0.49	2.7
Conventional oil No. 1	0	0	0.0(0)	0.1(9)	1–	0.0(0)	47.8	0.06	>1000
	18	0.5	0.0(4)	0.1(0)	1–	0.0(0)	37.4	0.05	40.0
	206	4.57	0.2(5)	2.(7)	2–	0.0(1)	16.5	0.09	7.2
	437	7.01	0.6(0)	6.(6)	2½–	0.0(1)	15.7	0.20	3.7
	618	8.40	1.1(0)	7.(1)	2½–	0.0(1)	14.8	0.48	2.8
	824	9.58	1. (5)	11.(5)	3–	0.0(2)	14.5	0.42	2.0
	1957	21.75	3. (5)	22.(8)	4–	0.0(2)	13.6	1.61	0.32
Conventional oil No. 2	0	0	0.0(0)	0.1(1)	1–	0.0(0)	41.2	0.08	680
	20	0.50	0.0(6)	0.1(0)	1–	0.0(0)	37.2	0.15	12.0
	206	4.30	0.2(7)	2.(4)	2	0.0(1)	15.4	0.26	2.2
	412	7.31	0.7(0)	4.(5)	2½–	0.0(1)	13.5	0.17	3.0
	618	9.74	0.8(6)	6.(1)	2½	0.0(1)	12.4	0.17	2.2
	824	12.13	1.3(5)	9.(1)	3–	0.0(1)	12.3	0.38	1.2
	1545	21.24	1.9(7)	13.(5)	4–	0.0(2)	11.3	1.42	0.2

[a] The saponification number of the fresh inhibited oil is slightly greater than that of the base oil without inhibitor (0.0 (6) KOH per g.) but this is negligible in comparison with the increases in saponification number which uninhibited oils exhibit upon even brief oxidation.
[b] 1946 Book of A.S.T.M. Standards, Part III-B.
[c] M.I.T. cell, 100 v. per 62 mils.

new oil showed similar decreases in tensile strength.

Consideration of the above data indicates that the presence of a carefully selected antioxidant in a transformer oil does not alter the essential properties of a new oil and, by preventing appreciable oxygen absorption, serves to preserve these characteristics for an extended period.

Blending of Oils from Various Sources

Attention has been drawn to the possibility of untoward effects following the blending of two or more oils from different manufacturers (8). However, several experiments have shown that blending an inhibited and an uninhibited oil results only in lowering the stability of the more oxidation-resistant component. In no case is the stability of the mixture less than that of the uninhibited oil. Furthermore, blending two inhibited oils follows the same pattern, that is, the stability lies somewhere between that of the two components, and no precipitation nor discoloration was observed in any of the mixtures. (Care should be taken when adding new oil to a transformer already containing oxidized oil, owing to the danger of the precipitation of incipient sludge that may possibly occur under such circumstances.)

Stability Tests in Full-Size Transformers

Tests were recently completed on transformer oils in two 5-kva. pole type transformers wired in opposition under overload conditions, the top oil temperature being thermostatically controlled at 90 C. throughout the test period of 1 yr. The units contained 5 gal. each of an inhibited oil and of a conventional uninhibited transformer oil with free access of air. At the conclusion of the test the conventional oil had attained an acid number of 0.5 mg. KOH per g. with the concurrent formation of 0.13 per cent by weight of sludge. On the other hand, the acid number of the inhibited oil, which contained ample active antioxidant, was less than 0.1 mg. KOH per g. and, since oxidation had not occurred, no true sludge was present. Because of sludge deposition, which impaired normal cooling, the coil temperature of the unit containing the conventional oil increased from 101 to 111 C. during the test period. Corresponding temperatures for the inhibited oil were 96 and 97 C. Like increases were noted in the iron-lamination temperatures.

Tests of this type, although somewhat lengthy and difficult to conduct, offer more convincing evidence of relative oil stability than laboratory methods, since the material is evaluated in an environment of metallic catalysts, cotton, varnish, etc., which is identical to service conditions. This is of particular importance when investigating new developments which have not been extensively used in commercial practice.

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(2) W. G. Horsch, "Oxidation Testing of Transformer Oils," *Electrical World*, Vol. 126, No. 5, p. 54; No. 7, p. 72; No. 9, p. 56 (1946).

(3) A. A. Pollitt, "Oxidation Tests for Transformer Oils," *Journal*, Inst. Petroleum, Vol. 32, p. 414 (1946).

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(5) R. G. Larsen and F. A. Armfield, "Catalysis in the Oxidation of Lubricating Oil," *Ibid.*, Vol. 35, p. 581 (1943).

(6) H. H. Zuidema and G. W. Waters, "Ring Method for Determination of Interfacial Tension," *Ibid.*, Anal. Ed., Vol. 13, p. 312 (1941).

(7) H. Stager, "Uber den Angriff von Baumwolle durch Mineralöle bei höherer Temperatur," *Helv. Chim. Acta*. Vol. 11, p. 377 (1928).

(8) L. J. Berberich, "Oxidation Inhibitors in Insulating Oils," *Electrical World*, Vol. 123, No. 7, p. 90; No. 9, p. 86 (1945).

MR. E. R. THOMAS.[1]—I should like to ask Mr. Larsen two specific questions. I should be interested specifically in how you made the resistivity measurement—the technique of it.

The second question is: exactly how did you run your cell to get data on neutralization numbers, for example, at various periods of time. In other words, was a sample withdrawn from an individual cell, or were there a number of cells running parallel, and you took data by discontinuing one of the cells and using that oil to determine a point.

MR. R. G. LARSEN (*author*).—The resistivity was measured with a Leeds & Northrup test set at 500 v. d-c. potential. The oil was contained in a two terminal measuring cell built by Mr. Balsbaugh. The general procedure is that described in A.S.T.M. Standard Methods of Test for Insulation Resistance of Electrical Insulating Oils (D 257 – 38)[2] and the volume resistivity expresses in ohm-cm. units.

In answer to the second question, we made individual runs for each point on the curve. The run was terminated either at a given amount of oxygen absorbed or, as in the case of an oil showing an induction period, at a given time.

MR. WILLIAM G. HORSCH.[3]—I should like to ask Mr. Larsen whether the transformers which he has been running were freely open to the air or closed.

MR. LARSEN.—We drilled two holes in the top of the cover and put in $\frac{1}{4}$-in. pipe elbows, so the oil was exposed to the air more than it normally would be in that particular transformer. The elbow was used so there would be no dust falling directly in.

MR. HORSCH.—I have been very much interested in Mr. Larsen's work, because we have been carrying on transformer tests for over a dozen years. Our transformers are freely open to the air.

As Mr. Berberich has mentioned in his paper, I too am neutral on this question of inhibitors. I believe that if the use of inhibitors proves to be economically sound and if all the practical aspects of the problem, of which there are a great many, are worked out in favor of the inhibitors, they should and will be used. The big problem is the testing. While we have obtained some results which resemble Mr. Larsen's in being very clear-cut—that is, the transformer tests check the laboratory tests—in other cases we have found just the opposite to be true. Since it takes years to make the test in transformers, it is a very long drawn-out problem to work out some of these relationships.

We have examined inhibited oil that looked very favorable in a test in which oxygen is absorbed very slowly at first and then rapidly after a rather long induction period. The same oil in other laboratory tests at no higher temperature showed relatively little improvement over a conventional oil. Finally, this oil when tested in the transformer was actually slightly inferior to the conventional oil. We have not wholly explained this behavior but the results are indicative of the fact that an oil should not be chosen solely on the basis of laboratory oxidation tests.

Our transformers are of small size and the amount of copper exposed is relatively slight. I wonder whether Mr. Berberich would suggest that we ought to increase the amount of copper exposure in some way in order to make our tests simulate more nearly actual commercial field conditions.

MR. LEO J. BERBERICH.[4]—I believe that Mr: J. G. Ford, of our Sharon Works, can answer that question better than I can. I might say that it would be well to run these transformers both ways to get tests representative of what happens in a power transformer as well as in a distribution transformer, keeping in mind the proper ratio of copper to oil, and the surface relationships with respect to the volume of oil and gas space in the two cases. In a distribution type of transformer the copper wire is essentially covered with enamel and, therefore, is largely out of the picture. This is not the case in a power transformer.

MR. J. G. FORD.[5]—I think the first thing we should do, when we say transformers, is to remember that we are generalizing. In the first place, transformers are made by numerous manufacturers; different processes are used for processing the coils; different amounts of copper are exposed, etc. So, to make a simple test in a transformer with inhibited oil is no conclusive evidence that inhibitors will work in transformers generally.

As to the amount of copper exposed, of course, that can vary. It may vary in different transformers of the same manufacturer depending on the size.

As far as the use of inhibitors in transformers is concerned, as a representative of a manufacturer of electrical equipment, I do not draw any lines on the use of inhibitors. I say if inhibitors are good for the preservation of transformer oil, we should use them. It is a question more or less of economics, as Mr. Berberich pointed out, and particularly the economics with respect to the type of transformer. For instance, it might be good economics to use an inhibitor in a free breathing transformer, and very poor economics to use an inhibitor in a sealed transformer such as a network transformer with a welded cover where oxygen is not a serious problem.

Again, the inhibitor adds cost to the oil and that cost must be justified.

I think in general that time will tell whether inhibitors will have a place in the use of transformers, that is certain types of transformers, but I do not think we should discount the value of a thermo-syphon type of oil filter which I believe makes the use of an inhibitor unnecessary. It might also be argued conversely that, regardless of what type of transformer one may use, the inhibitor will add life. I think that is also true. Again, it comes down to the question of economics and developed experience before we

[1] Test Engineer, Electrical Engineering Dept., Consolidated Edison Co. of New York, Inc., New York, N. Y.

[2] 1946 Book of A.S.T.M. Standards, Part III-B, p. 135.

[3] Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

[4] Manager, Physical Section, Insulation Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

[5] Manager, Manufacturing Engineering, Westinghouse Electric Corp., Sharon, Pa.

can know definitely just what the best economics is.

MR. LARSEN.—I agree with what has been said about the meager data with regard to the actual advantage of an inhibited oil in transformers, I should like to cite one other case where this type of material has been tested. Last week in Riverside, Calif., at a meeting of the Pacific Coast Electrical Assn., a discussion of inhibited transformer oils was held similar to this one. At that meeting a representative of one of the utilities described tests that had been made in 15-kva. transformers. Six oils were tested and it was concluded that the inhibited oil was definitely superior and they felt quite justified in its use. I wanted to see what condition the transformers were in, but was told that the results were very conclusive in favor of inhibited oil. Again, those tests were accelerated transformer tests similar to the ones I described. We do not have the data, of course, from the field.

MR. C. A. JOHNSON.[6]—I should like to ask Mr. Larsen whether he has not found some inhibitors which would lower the interfacial tension. Do they have any effect on interfacial tension in the original oil so that you might get a low reading first? I have heard of some that have that effect.

MR. LARSEN—Yes, some inhibitors may do that. I might also state that the varnishes picked up in the transformers have quite an effect on interfacial tension. So the interfacial tension of an oil in actual use can be affected by a great many things. The particular inhibitor we have in this oil does not affect interfacial tension—there are some materials, or quite a few materials which will, and we would agree with Mr. Fawcett that interfacial tension seems to be a much more sensitive measure of small changes in oil than most of the other conventional tests.

MR. E. F. WALSH.[7]—The paper by Reamer and Larsen presents data which every operator of oil-filled electrical equipment should note. The addition of antioxidants to well-refined insulating oils from selected crudes marks a great advance in the insulating oil field.

Laboratory and field experimental work by our company confirms the findings of the authors.

For the past six years practically all new oil replacements in our equipment have been of the oxidation inhibited type. Network transformers located in sidewalk vaults are difficult to service and therefore should contain the best liquid dielectric available. It should not be necessary to remove transformers from these locations for the purpose of changing the insulating oil. This results in unnecessary maintenance costs and reduces the capacity of the network system.

Conventional uninhibited insulating oils in transformers of this type have had to be replaced after ten years of service. Preliminary investigations with oxidation inhibited insulating oils indicates at least 30 years of nonsludging life. This extended oil life will mean decreased maintenance costs and increased reliability of the circuits involved.

One of the arguments against the use of oxidation inhibited oils has been the lack of reliable tests for following the life expectancy of these oils. With the development of a simplified method of determining the interfacial tension value of an oil, it is no longer a mystery as to what is happening to inhibited oils in service.

[6] Socony Vacuum Oil Co., Inc., New York, N. Y.

[7] The Narragansett Electric Co., Providence, R. I.

Oxidation Inhibitors in Electrical Insulating Oils

By Leo J. Berberich[1]

IT IS WELL known that the principal products of oxidation in petroleum oils are peroxides, acids, water, and sludge. It is also well known that when small amounts of certain compounds, called inhibitors or antioxidants, are added to the oil, the formation of these products is retarded. The use of inhibitors in insulating oils, however, has not been extensive so far, despite the fact that they are widely used in almost all other petroleum products.

It is the purpose of this paper to discuss the reasons for this and to review some of the problems which the electrical industry faces in attempting the general use of inhibited oils in all electrical apparatus. Specifically, the complex nature of petroleum oils, the influence of refining on properties, and the mechanisms of oxidation and oxidation inhibition are discussed briefly. This is followed with some laboratory test results on representative inhibited oils and a discussion of some practical considerations pertaining to the use of inhibited oils.

COMPLEX NATURE OF PETROLEUM HYDROCARBONS

Petroleum is an exceedingly complex mixture of hydrocarbons. It is so complex that only some very general information is available regarding the higher boiling fractions, among which are transformer and cable oils. Much effort has been expended in determining the composition of petroleum fractions. The most outstanding work in this direction is that undertaken by the American Petroleum Institute at the National Bureau of Standards (1).[2] The work was started in 1927 on a typical Oklahoma (mid-continent) crude oil. By a careful distillation, the crude oil was separated into the fractions shown in Fig. 1. The last fraction, called the "resid-

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[2] The boldface numbers in parentheses refer to the references appended to this paper.

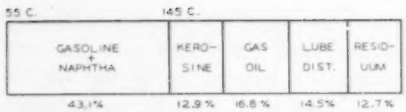

Fig. 1.—Fractions from South Ponca Field Crude Oil Under Investigation in American Petroleum Institute Project No. 6 (Rossini).

uum" is a heavy cylinder stock which is too high boiling to distill without decomposition.

Transformer oil is derived from the gas-oil fraction and cable oil from either the lubricating oil distillate or the residuum fractions. Transformer oils, however, are not usually made from mid-continent (mixed-base) crude oils, but from naphthenic base (coastal) crude oils because the latter have certain desirable properties, particularly low pour points. Cable oils have been made from all of the three main types of crude oils, although most of the present cable oils are also derived from coastal crude oils.

After many years of work on the gasoline and naphtha fraction, F. D. Rossini (1) and his associates have succeeded in the isolation of more than one half of the one hundred known hydrocarbons boiling between 55 and 145 C. One example of each of the three major types of hydrocarbons found in this fraction is illustrated by the first three structures given in Fig. 2. This fraction is richest in the paraffinic type and poorest in the aromatic type, the naphthenic being intermediate. The last type listed in Fig. 2, namely, the olefinic type, was not found in this fraction. There is evidence, however, that it exists in the higher boiling fractions, probably as side chains in some of the ring structures. This type is similar to the paraffinic type except that it contains one or more double bonds. The general stability is highest for the paraffins and least for olefins. The latter are readily attacked by such reagents as oxygen and mineral acids.

The higher boiling fractions are far more complex and the complexity increases with the boiling point. The properties of the individual hydrocarbons lie closer together, which makes it exceedingly difficult to separate them. No single individual hydrocarbon has, to the author's knowledge, ever been isolated from the lubricating oil fraction. Only the carbon-to-hydrogen ratios, the average molecular weights, and the general molecular formulas have been determined. Besides pure hydrocarbons, all crude oils contain minor proportions of compounds having sulfur, nitrogen, and oxygen in their molecular make-up which are largely removed by the refining process.

The foregoing discussion indicates the complexity of the problem of studying the reactions which insulating oils may enter into with oxygen and other deteriorating influences. This applies even more so to the study of inhibitors, since the behavior of any specific inhibitor varies and usually depends on the nature of the oil to which it is added. There is, however, considerable evidence that the hydrocarbons in the moderately refined insulating oils used in this country consist largely of a mixture of naphthenic and aromatic hydrocarbons, or the second and third types listed in Fig. 2. The paraffins are largely absent in the higher boiling fractions except that in certain crude oils, especially in paraffinic (Pennsylvania) crude oils, they are present as waxes which are removed by modern methods of refining.

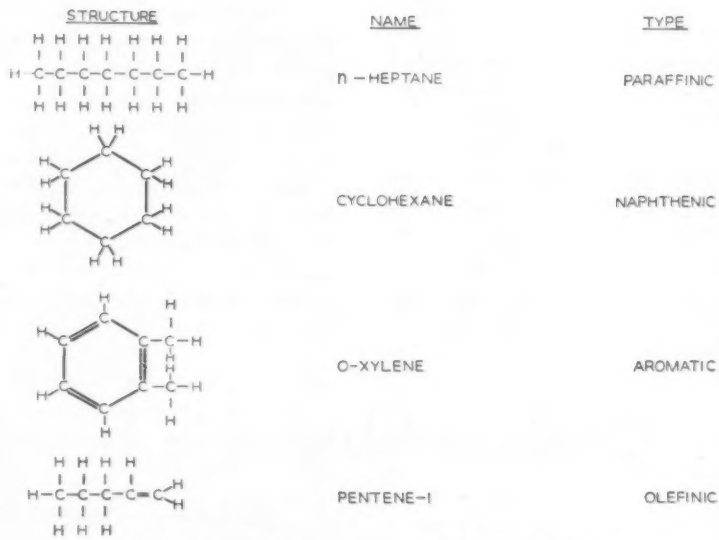

Fig. 2.—Typical Hydrocarbons in Gasoline Fraction.

Influence of Refining

The most common method of refining (2) insulating oils consists of treating the distillate with sulfuric acid, neutralizing it with caustic soda, and finally filtering it through activated clay. The newer solvent-refining methods have also been employed, but not with so much success. Of the many available selective solvents, sulfur dioxide appears to be the most promising in the refining of transformer oils. The properties of the finished oil depend not only on the degree of refining, but also on the nature of the crude oil. In general, refining removes, first of all, the compounds containing sulfur, oxygen, nitrogen, and those containing olefinic double bonds. As the severity of the refining treatment is increased, the aromatic compounds are removed in increasing amounts. Finally, after very severe treatment, only the naphthenes (and the paraffins, if any are present) remain. This gives a very brief and much simplified picture of the functions of the refining process.

Most of the early transformer oils of petroleum origin were rather highly refined and usually derived from paraffin-base crude oils. The conservative design and the low temperatures of operation of the early transformers enabled these oils to give a good account of themselves. The higher temperatures in the modern transformers, however, brought to light that such oils readily form acids in service. The

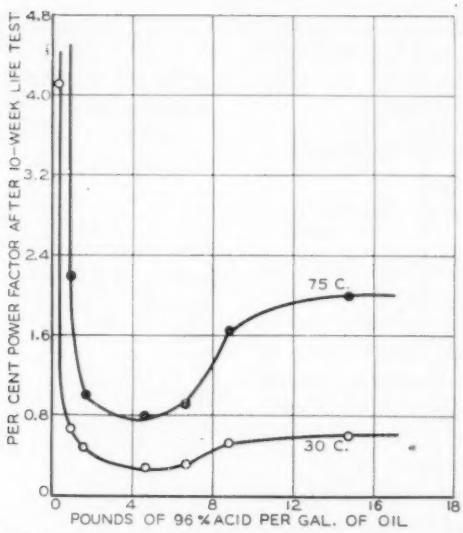

Fig. 3.—Effect of Severity of Acid Treatment on Stability of Oil-Treated Insulation (Clark).

low molecular weight portions of these acids in combination with water corrode the metal parts of the transformer. They are also strongly absorbed by cellulose which results in a marked increase of the power factor of the cellulosic insulation used in the transformer. The actual attack and eventual destruction of cellulose is probably not entirely due to acids, but to their forerunners, namely, the peroxides. This behavior of highly refined oils stimulated many investigations which had for their purpose the determination of the best type of crude oil and the optimum degree of refining. All of this work, done in a number of places, led to the choice of a naphthenic crude oil and to the conclusion that highly refined oils readily form acids and lightly refined oils readily form sludge. A moderately refined naphthene-base oil was found to be the best compromise, which led to the adoption of this type of oil for transformer use in this and many European countries. The wisdom of this choice is borne out by the very favorable service record shown by modern transformer oils.

Similarly, for cable and capacitor impregnants, moderately refined naphthenic oils are also desirable from the standpoint of maximum stability. Clark and Raab (3) investigated the effect of degree of refining on the performance of experimental capacitors under voltage stress in an accelerated life test. They used power factor as the criterion of stability and some of their results are shown in Fig. 3. These data indicate, for the particular naphthenic oil investigated, that about five pounds of 96 per cent sulfuric acid per gallon of oil results in maximum stability. It was also shown that the oil refined to this extent contains a substantial proportion of aromatic hydrocarbons which are not usually found in paraffinic crudes.

It is believed that stability of oil in impregnated paper cables and capacitors is primarily related to stability to gaseous electric discharge, and that oxidation stability is a secondary requirement. It has been shown by the author (4) and others that oils containing substantial proportions of aromatic hydrocarbons produce very little gas when subjected to electric discharge. This work showed, furthermore, that the stability of a highly refined oil can be improved markedly by adding a simple aromatic hydrocarbon such as diphenyl. This provides a method for remedying a deficiency in paraffinic oils, although a not entirely satisfactory one.

It is thus evident that the degree of refining in a naphthene-base insulating oil should not be carried to the point where all aromatic hydrocarbons are removed, whether the oil be for transformer, cable, or capacitor use. In transformer oils, where oxidation is the only important deteriorating influence, it is doubtful, however, that aromatic hydrocarbons, as found in petroleum, are basically much more stable to oxidation than naphthenic hydrocarbons. Larsen (5) and coworkers have made a study of the oxidation behavior of the various classes of pure hydrocarbons and they found that many of the aromatic compounds possessed the ability of self-inhibition or autoretardation. This retardation occurs only after some oxidation has taken place, indicating the formation of phenolic type of inhibitor. In addition to the possibility of self-inhibition, petroleum oils are believed to contain natural inhibitors of an aromatic nature. Overrefining the oil not only eliminates all of the aromatics, but also the inhibitors. The fact that the most effective synthetic inhibitors are derivatives of aromatic hydrocarbons lends some support to this view. Thus, oil stability is very likely more strongly dependent on the presence of natural inhibitors than on hydrocarbon types.

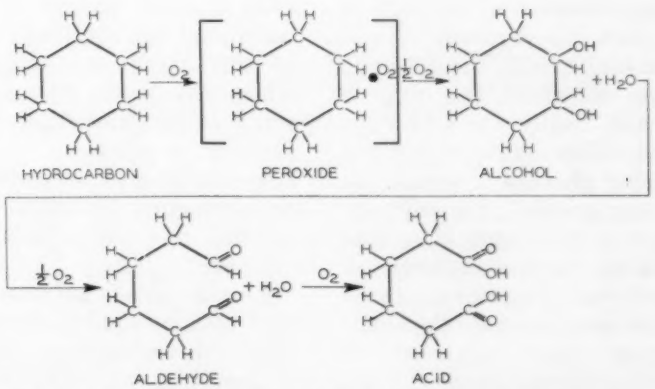

Fig. 4.—Various Stages of Oxidation of Naphthenic Hydrocarbon.

Oxidation Mechanism in Hydrocarbon Oils

Because of the complex nature of petroleum hydrocarbons, the oxidation mechanism is necessarily also complex. Studies of various types of simple hydrocarbons by kinetic methods have, however, resulted in considerable elucidation of some of the reactions which hydrocarbons undergo. It is now generally believed that most of the oxidation reactions proceed by a chain mechanism. A simple chain reaction may be illustrated in the following manner:

$$A^* + O_2 \rightarrow A.(O_2)^*$$
$$A.(O_2)^* + A \rightarrow A.(O_2) + A^*$$

where the asterisk indicates an energy-rich or activated molecule and A is a hydrocarbon molecule. The chain reaction starts with an activated hydrocarbon molecule which can be either a free radical or a molecule which has received energy from some external source such as ultraviolet light. This activated molecule reacts with oxygen to form an activated oxygen complex $A.(O_2)^*$. The oxygen complex, in turn, reacts with an ordinary hydrocarbon molecule to form an ordinary oxygenated hydrocarbon molecule and an activated hydrocarbon. Thus, the activated hydrocarbon is reproduced and the reaction can start over again and go on indefinitely until the chain is terminated in some manner. This is discussed further in several recent reviews (6, 7) of the mechanism of oxidation of liquid hydrocarbons.

A purely hypothetical illustration of the various stages of oxidation through which a simple naphthenic hydrocarbon, namely cyclohexane, may go is shown in Fig. 4. First, the oxygen complex or peroxide is formed, then the hydroxyl or alcohol derivative, next, the aldehyde derivative in which the ring is severed, and, finally, the acid stage is reached. This indicates only one of a number of ways in which the reaction may proceed. For example, the ring may be broken in several places and the reaction on one end of the hydrocarbon fragment may proceed faster than on the other end. Some more recent evidence (6) indicates that the oxidation may not proceed through the alcohol stage and that the ketone, in addition to the peroxide, may be a key oxidation intermediate. This may be illustrated as follows:

Hydrocarbon → Peroxide → Alcohol
↓
Ketone → Further oxidation products

The course of reaction can vary from one hydrocarbon type to another. Much more work appears to be necessary before the exact course of reaction of even a simple hydrocarbon can be predicted.

Water is formed in several of the oxidation stages shown in Fig. 4. That a relatively large amount of oxygen goes into the formation of water is indicated in Fig. 5. These

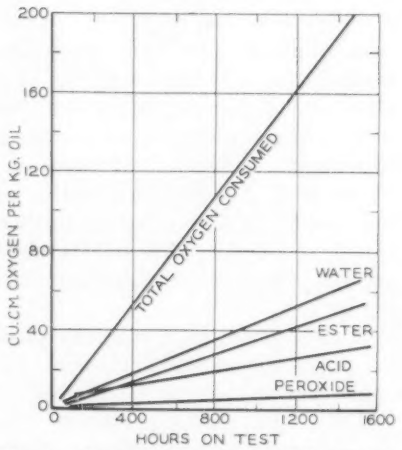

Fig. 5.—Oxygen Balance for Oil Aged in Closed Vessel (Larsen).

data, obtained by Larsen (8), show the oxygen balance for an oil aged in a closed vessel in the presence of oxygen. By far the major portion of the oxygen consumed by the oil went into the formation of water. Only a small amount of peroxide was found, but this is to be expected of this highly transitory product which soon passes into more stable forms of oxygenated products. No alcohols or aldehydes were found, but considerable oxygen went into the formation of esters which are reaction products between alcohols and acids.

Certain metals are always in contact with insulating oils in service. Some of the metals, particularly copper, iron, and lead catalyze or accelerate the oxidation reactions, copper being the most active in this respect. These metals can also react with the organic acids to form metal salts or soaps. These soaps not only affect the electrical properties of the oil, but those arising from the higher molecular weight acids may come out of solution and deposit on various parts of the transformer. The other solid products formed, and normally referred to as sludge, are the result of secondary polymerization and condensation reactions of partially oxidized products. Sludge does not form in a properly refined oil until some considerable attack by oxygen has taken place. Thus, it is apparent that all of the undesirable products formed in transformer oils can be directly attributed to oxidation. Moreover, the importance of preventing or limiting oxidation of the oil in this type of apparatus is indicated.

Mechanism of Oxidation Inhibition

In the early days of the petroleum industry, it was thought that whatever resistance to oxidation a hydrocarbon oil possessed, it was due to its inherent stability. This idea persisted until the classical work of Moureu and Dufraisse (9) revealed the existence of oxidation inhibitors. These investigators showed that the addition of exceedingly small amounts of certain compounds to hydrocarbons often altered the course of the oxidation to a marked degree. As a result of this important original work, many substances have been found which respond to oxidation inhibitors. Among these are petroleum oils, vegetable and animal oils, fats, waxes, and rubber.

What little is known of the mechanism of oxidation inhibition indicates that the action of all inhibitors depends to some extent on their own oxidizability. Since inhibitors are effective in very small concentrations, it is reasonable to assume that they must in some way interrupt the chain reaction previously discussed. Therefore, one might picture the alteration of the second step in the chain reaction upon addition of inhibitor B in the following manner:

$$A.(O_2)^* + B \rightarrow A(O) + B(O)$$
$$A(O) + B(O) \rightarrow A + B + O_2$$

According to this picture then, the inhibitor disrupts the activated hydrocarbon complex and becomes oxidized in the process. The oxygenated hydrocarbon and oxygenated inhibitor, according to Moureu and Dufraisse, are supposed to be mutually antagonistic and, therefore destroy each other. Thus, in the second step, the hydrocarbon, inhibitor, and oxygen are regenerated. When the inhibitor is not present, the reaction between hydrocarbon and oxygen goes through the peroxide and several other stages until finally water, acids, and sludge are formed. The mechanism just described cannot be strictly correct, since it requires that no inhibitor be consumed. While it is known that the inhibitor is eventually consumed and that the oxidation then proceeds as if no inhibitor had been added, the fact that a small amount of inhibitor retards the action for such a long time leads one to believe that there must be at least an element of truth in this mechanism.

Some Laboratory Test Results on Inhibited Oils

Many papers and patents have appeared in the technical literature of the past twenty years describing compounds that are effective in retarding the oxidation reaction in oils. The more important of these compounds are the aromatic amines, sulfides, disulfides, phenols, phosphates, and thiophosphates. There are also some compounds which appear to owe their effectiveness to either deactivation of the metal surface or reaction with the metal surface in such a way as to eliminate its catalytic action. Certain compounds containing phosphorus, sulfur, or chlorine appear to have this property. There is still another type which is believed to act as a "sludge solvent," thus increasing the solubility of the oil for sludge. Certain aromatic nitro compounds are effective in this respect.

It is practically impossible to compare the effectiveness of the many compounds described in the literature, because the test conditions differ widely. There is no standard test for evaluating inhibitors and the need for one is apparent. The development of a test that will be representative of conditions in service, however, would be a major research problem in itself. Horsch (10) has found, for example, that none of the ordinary laboratory test results can be correlated with the behavior of various oils in an accelerated field-service test in transformers operated under controlled conditions. Laboratory tests, however, are of value as control tests and give a good indication of oil behavior toward oxygen in a relatively short time. In view of this situation, the laboratory test results on only a few typical inhibitors and on some commercially available inhibited oils will be discussed.[3]

Trautman (11) investigated a number of inhibitors in a typical transformer oil. The tests were carried out at 120 C. in the presence of air and copper. The time required to form a fixed and conveniently measurable amount of sludge was used as the test criterion. Some of Trautman's results are given in Table I.

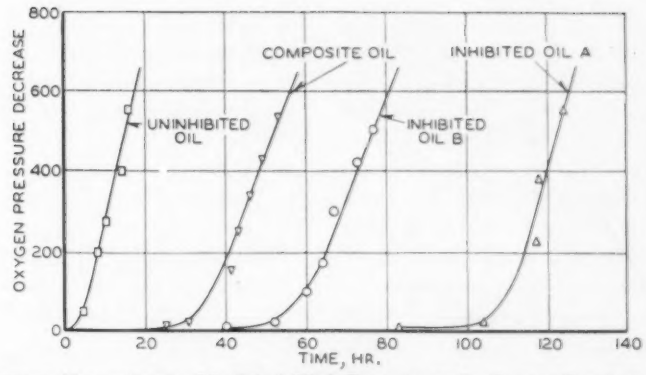

Fig. 7.—Oxygen Absorption by Modified Sligh Test at 120 C., Copper Catalyst (Mahncke)

TABLE I.—EFFECT OF VARIOUS INHIBITORS ON SLUDGE FORMATION IN TRANSFORMER OIL.

Inhibitor and Amount Added, per cent by weight	Time to Form 0.1 per cent Sludge, days
None, oil alone	7
Benzyl-p-anisidine, 0.1	17
Benzyl-p-anisidine, 0.5	>60
Benzyl-p-anisidine, 0.1 plus 2,6-di-tert-butyl-4-methylphenol, 0.3	>60
2,6 - di - tert - butyl - 4 - methylphenol, 0.3	14
Benzyl aniline, 0.3	11
Trithiophenyl phosphate, 0.3	22
Trithiophenyl phosphate, 0.3 plus 2,6-di-tert-butyl-4-methylphenol, 0.3	52

It will be observed from this tabulation that relatively large amounts of the various inhibitors were added. This appears to be necessary in moderately refined oils in contrast to highly refined oils where marked effects can be observed with much

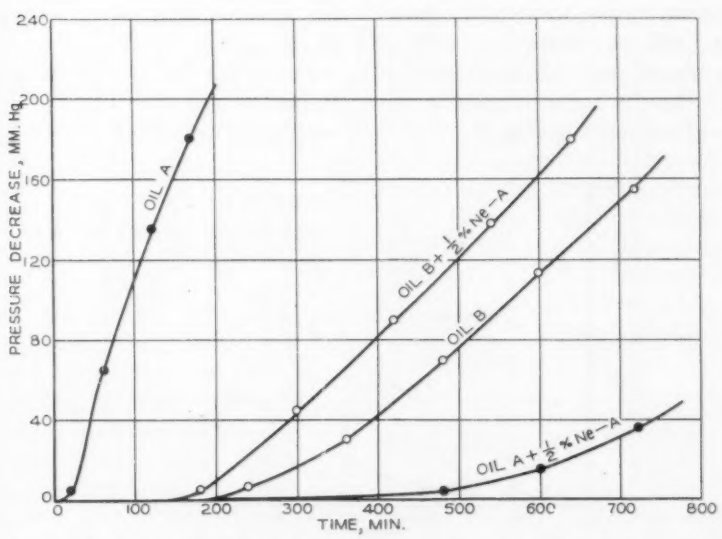

Fig. 6.—Oxygen Absorption by Modified Sligh Test at 175 C., No Catalyst (Mahncke).

[3] Many of the data which follow were obtained by H. E. Mahncke of the Westinghouse Research Laboratories to whom the author wishes to express his thanks.

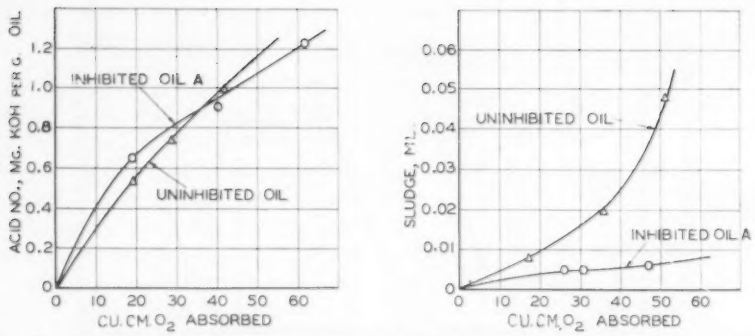

Fig. 8.—Relationship of Oxygen Absorption to Acidity and Sludge Formation for Inhibited and Uninhibited Oils.

smaller concentrations. The amino compound, benzyl-*p*-anisidine, appears to be the most effective of the group. The table also shows that a combination of two inhibitors is more effective than either inhibitor alone in the same total concentration. This has been observed before, but is not always found to be the case.

In certain cases the same compound may act to inhibit oxidation in one type of oil and promote oxidation in another type of oil. Figure 6 shows a striking example, data for which were obtained by using a modified Sligh test described by Davis (12) and coworkers. Decrease in oxygen absorption or in oxygen pressure with time in a closed system at 175 C. with no metal catalyst was used as the test criterion. Oil A is a naphthene-base oil having a viscosity index of 76 and oil B is a paraffin-base oil having a viscosity index of 105, both being special lubricants and not intended for insulating applications. The two oils were aged with and without 0.5 per cent of Neozone A (phenyl - alpha - naphthylamine). This inhibitor is quite effective in oil A, but, surprisingly enough, promotes oxidation in oil B. Very similar results were obtained when the aging was carried out at 100 C. in the presence of brass, iron, zinc, and aluminum. The time scale in this case, however, was in hundreds of hours instead of hundreds of minutes.

This behavior is perhaps abnormal, but it is not unusual for certain inhibitors to show considerable effect in one type of oil and little or no effect in another type of oil. Thus, the specific action of inhibitors further complicates their evaluation and use. For example, it is not a difficult matter to find compounds that are effective in oils refined to the point where they approach a white oil, but many of the same compounds have little or no effect in conventionally refined transformer oils. Horsch (10) has shown that highly refined oils of the British A-30 type can be inhibited to produce a reasonably long life in a transformer. Inhibited white oils, however, have several disadvantages which should not be overlooked. These are: (1) their cost is considerably higher than that of a conventional transformer oil, and (2) acidity forms at a very rapid rate when the inhibitor is consumed.

The oil industry has made considerable advances in the last few years in the direction of finding inhibitors that are effective in moderately refined oils. A number of these oils are now commercially available. The results of oxygen absorption tests at 120 C. in the presence of copper for two of these inhibited oils in comparison with a regular transformer oil are shown in Fig. 7. Results for a composite oil sample also shown in Fig. 7 will be discussed later. The conventional oil starts to absorb oxygen within about 1 hr. after the start of the test, while the inhibited oils do not absorb an appreciable amount of oxygen until about 50 to 100 hr. after the start of the test. This time delay in the start of oxidation is commonly called the "induction period." It will also be observed from Fig. 7 that after the induction period the rate of oxygen absorption is approximately the same for both types of oils. It is interesting, also, to note that the curves in the left hand part of Fig. 8 show that the acid number as a function of the volume of oxygen absorbed is roughly the same for the inhibited oil as for the uninhibited oil. The right hand part of Fig. 8 shows, however, that the sludge formed per unit of volume of oxygen absorbed is decidedly less for the inhibited oil than for the uninhibited oil.

The foregoing data are typical of the aging behavior in the presence of copper found for six different inhibited oils obtained from various suppliers, except that the length of the induction period varied considerably. The sludging characteristics of all of these oils were not investigated; therefore, it cannot be said that the sludge curve for inhibited oil A shown in Fig. 8 is typical of all of the oils. But the correlation between oxygen absorption and acid numbers was essentially the same for all six of the inhibited oils as well as three uninhibited investigated.

These aging tests were repeated in the absence of a copper catalyst on the same three oils whose behavior with copper has just been described in connection with Fig. 7. There is ample justification for a test without

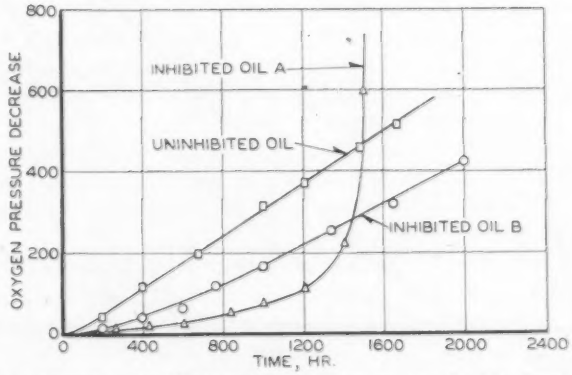

Fig. 9.—Oxygen Absorption by Modified Sligh Test at 120 C., No Catalyst (Mahncke).

copper, because in many of the smaller transformers as now manufactured, copper is effectively eliminated by covering it with varnish or wire enamel. The results of these tests are given in Fig. 9. It will be observed that the behavior is quite different from that found with copper. There is no well-defined induction period, and the oxygen absorption is more gradual. The behavior of inhibited oil B is typical of five of the inhibited oils investigated. The sixth oil, inhibited oil A, shows low oxygen absorption in the early part of the test, but after about 1400 hr., the oxygen absorption increased rapidly until at 1500 hr. the oxygen absorption exceeds that for the conventional oil. This oil appeared to be somewhat more highly refined than the other inhibited oils and perhaps this explains its peculiar behavior. Whether an oil of the type of inhibited oil A will perform better than the conventional oil can be settled only by long-time tests in transformers. It is interesting to note that the acid number at the point where the curves for these two oils cross is about 1.1 mg. KOH per gram of oil.

Practical Considerations

As stated early in this paper, only little use has been made of inhibitors in insulating oils up to the present time. In striking contrast, inhibitors have come into quite extensive use in various types of lubricating oils and internal combustion engine fuels. Some of the more important factors that have a bearing on this question will now be discussed in some detail.

Evaluation of Inhibited Oils in Terms of Service Life:

Perhaps the most important single factor that has retarded general acceptance of inhibitors in insulating oil applications is lack of field experience. Since the life of insulating oil is long, ten years or more, the evaluation of inhibited oils in terms of performance in a transformer, for example, requires a long time. The fact that it has so far been impossible to correlate results of laboratory tests with tests in transformers has complicated the matter still further. It is understood that some field experience is being obtained and also some controlled tests in transformers are being carried out in several places on representative inhibited oils. Since tests of this type require a long time, results cannot be expected in the near future.

Aside from requiring a long time, tests in transformers can yield varying results depending on: (1) the other materials exposed to oil in the transformer, (2) the degree to which oxygen is excluded, and (3) the degree to which the deterioration products are permitted to escape from the transformer.

The use of oil-resistant synthetic varnishes in recent years has practically eliminated the varnish as a variable. The amount of copper exposed to the oil, however, is a very important variable. In the smaller transformers, where enameled wire is used, copper is practically removed from the picture, but in the larger transformers, much of the copper is exposed. Comparison of the data in Figs. 7 and 9 indicate that large differences can be expected in the two cases. Transformers are also operated under varying conditions of exposure to atmospheric oxygen which introduces a second important variable in the behavior of the oil. If the products of oxidation cannot escape, it is well known that these products usually accelerate the deterioration of the oil. For example, Horsch (8) has shown that the presence of water in the transformer markedly accelerates the rate of sludge formation. Thus, it is indicated that test results in one type of transformer will very likely not be representative of the behavior of the oil in another type of transformer. Careful planning, therefore, is necessary in making tests in transformers to include the more important variables that are likely to be encountered in practice. When these variables are combined with variables in the inhibited oils, themselves, it is evident that a complete evaluation of inhibited oils is not a simple matter.

The Behavior of Oil Mixtures:

Every oil supplier usually develops his own inhibitors and their identity is usually a carefully guarded secret. Therefore, not only are differences in the base oils likely to be found from one supplier to the other, but also differences in inhibitors. For commercial reasons most of the electrical manufacturers must obtain oil from more than one supplier. Since segregation of oils from different suppliers is impractical for obvious reasons, the question arises: Can oils containing various inhibitors of unknown composition from different sources be mixed without serious consequences? In order to obtain some information on this question, a composite sample containing equal parts of six different inhibited oils and three different uninhibited oils was prepared. The oxygen absorption, acidity, and sludge were determined in the presence of copper at 120 C. on this composite sample and the results compared with similar test results on the individual oils. These results will not be reported in detail here, but it can be said that as far as oxygen absorption, length of induction period, and acid formation are concerned, the composite sample had values which approximated the averages obtained from tests on the individual oils. The results of oxygen-absorption tests on this composite sample are shown in Fig. 7 in comparison with those for three of the oils used in the blend.

The sludging behavior of the composite sample was different, however, in that more sludge was formed than the average of the values for the individual oils. Thus, as far as sludge formation is concerned, the composite sample appears to be influenced by the poorer quality oils. The same statements apply to similar tests made in the absence of copper catalyst. While these laboratory tests indicate that mixtures of various inhibited and uninhibited oils may be somewhat better than the poorest oil in the mixture, confirmation of this is desirable by long time tests in transformers. Even after tests in transformers confirm this result, compatibility tests will probably have to be repeated from time to time to ensure that compatibility is maintained and to check each new addition to the group of oils. The use of a single inhibitor which is effective in the ordinary transformer oil as now available from a number of

different suppliers would certainly simplify this problem. This does not appear likely to happen in the near future.

Universal Oil for a Number of Applications:

Not so many years ago, a different type of oil was used in each of the various types of electrical apparatus requiring oil. It has since been found, however, that the present type of American transformer oil will perform with equal satisfaction in a number of different types of apparatus. Therefore, the electrical industry adopted a so-called "universal oil," which is now being used in transformers, regulators, circuit breakers, impregnated paper bushings, and some paper capacitors. The only important application not now satisfied by the present transformer oils is impregnated paper cables, where oils of high viscosities are required. The use of a multipurpose oil has resulted in considerable savings in oil storage and oil-handling equipment. A return to the old practice of using a special oil for each application would be a decided step backward. Therefore, before inhibitors can come into general use, a sufficient amount of work must be done to insure that inhibited oils will not adversely affect any of the apparatus in which transformer oils are now used.

Since no mention has so far been made of circuit-breaker oils, a brief discussion of this application is in order. The oxidation-stability requirements for circuit-breaker oils are not as stringent as for transformer oils because the operating temperatures, in general, are lower. Additional oxidation stability might not be amiss, however, since there have been a few cases of corrosion difficulties in circuit breakers. The chief products of decomposition in this application are carbon and gaseous products consisting mainly of hydrogen and hydrocarbons. While the gaseous products may be a slight explosive hazard, they perform a valuable function in assisting the extinction of the arc. Carbon, on the other hand, performs no such useful function. It may be a hazard if it deposits on creepage surfaces and does not flocculate and settle to the bottom of the tank.

It does not appear likely that the addition of a small amount of inhibitor will appreciably alter the arc-interrupting characteristics of the oil. It is conceivable, however, that an inhibitor, usually polar in nature, may strongly influence the surface properties of the colloidally dispersed carbon formed during arcing. A change in the surface properties of the carbon through adsorption of the inhibitor may influence the rate of flocculation and settling or the degree of adhesion to vertical creepage surfaces. This is cited to illustrate the work that needs to be done in order to understand fully what the use of inhibited oils involves. Some work related to the behavior of inhibited oils in circuit breakers is under way in our organization, but it has not advanced to the stage where further discussion is justified at this time.

Other Methods of Improving Oil Performance:

The cost of inhibited oils is somewhat higher (10 to 100 per cent) than that for conventional oil, not only because of the cost of the added inhibitors, but also because special refining may be required in some cases to obtain optimum inhibitor response. Thus, from an economic standpoint, the cost of improving the performance of oil by the use of inhibitors should be compared with other methods of accomplishing a similar result. Such cost comparisons cannot be made at this time, however, because too little information regarding the performance of inhibited oils is available. But it may be well to review briefly some of these methods. The more familiar ones, most of which apply to transformers and may be classed as design improvements, are the following: (1) use of a conservator or expansion tank which limits the contact with the atmosphere, (2) use of special breathers which limit the moisture and oxygen intake, (3) use of nitrogen gas over the oil with nitrogen breathing arrangement which eliminates practically all contact with oxygen, (4) use of completely sealed tank with nitrogen in the gas space which also eliminates contact with oxygen, (5) use of continuous thermosiphon treaters containing an adsorbent material which removes the oxidation products as they are formed. These methods are all being used with varying degrees of success.

The last-named method, namely, the use of thermosiphon treaters, will be discussed further because it presents some interesting possibilities. Such treaters containing activated alumina have been described by Housley (13). Certain activated clays may also be used as adsorbents instead of alumina. The principle of removing the oxidation products as fast as they are formed appears to be sound. This type of treater is effective in removing moisture, acids and, possibly, the peroxides. As has been indicated previously, sludge does not form in a properly refined oil if the acidity is kept below predetermined levels. The acid value at which sludge first appears varies with the type of oil and the degree of refinement, and for the type of oil now in general use, it should be about 0.3 to 0.6 mg. KOH per gram of oil. It is only with poorly refined oils that sludge formation is likely to occur at very low acid values. Thus, if sufficient adsorbent is used in the treater to maintain the acidity below a certain low level for a given period of time, no sludge should appear. At the end of the period, the spent clay or alumina is either replaced or reactivated. The Aluminum Company of America has had about fifteen years of successful experience with this type of continuous oil maintenance.

The success obtained with most of these methods indicates that inhibited oils will receive serious competition, especially as far as recently manufactured equipment is concerned. The use of inhibited oils in relation to other methods of improving oil performance may be briefly summarized in the following way: (1) inhibited oils serve no useful purpose in apparatus in which contact with oxygen is completely excluded, such as is the case when nitrogen breathers or hermetically sealed tanks are used; and (2) inhibited oils should be of considerable value in apparatus in which there is limited or unlimited contact with oxygen, such as is the case when conservators, partially sealed tanks, or free breathers are used. But even in the second case, inhibited oils

should find a competitor in continuous thermosiphon treaters, especially in the large size units.

Summary and Conclusions

Despite the complex nature of petroleum hydrocarbons, the properties of the oil can be controlled to some degree by the selection of crude oils and careful refining procedures. The course of the oxidation reactions in petroleum oils and the manner in which these reactions are altered by the use of inhibitors are only partly understood. Laboratory test results on a number of available inhibited transformer oils indicate that some improved performance should be obtained by the use of inhibited oils over the conventional oils. Experience, however, indicates that the behavior of oils in transformers cannot be satisfactorily predicted by laboratory tests. Therefore, final evaluation of inhibited oils should be carried out in transformers. Unfortunately, such tests require a long time to carry out.

The more important factors which have retarded the general use of inhibitors in insulating oils are the following:

1. It is difficult to evaluate inhibited oils in terms of the long life usually expected of oils in electrical apparatus. Some progress in this direction is being made, however.

2. The use of different inhibitors by the various oil suppliers may bring about complicated storage and field-servicing problems unless it is shown that oils from various sources can be mixed without deleterious results. Recent laboratory data indicate that this problem may not be very serious.

3. The present transformer oils have, in recent years, become multipurpose oils in that they are now used in several different types of apparatus. Therefore, it must be shown that no undesirable effects are produced by the use of inhibitors in any of the applications for conventional transformer oils.

4. Inhibited oils cost more than the conventional oils. This increased cost has been variously estimated at 10 to 100 per cent, depending on the cost of the inhibitor and the degree of refining which the base oil receives. Reliable data are not yet available to determine whether the use of inhibited oils is justified from an economic standpoint.

5. Other methods of improving oil performance have been developed and some of these have been so successful that the use of inhibited oils becomes questionable. The more important of these involve elimination of access of the oil to atmospheric oxygen and the use of continuous adsorbent treaters to remove deterioration products as fast as they are formed.

In the face of the situation just described, it may be concluded that the electrical industry as a whole has not yet arrived at the point where a general shift from conventional oils to inhibited oils can be justified either from an economic or performance standpoint. It is realized that many operators have some old apparatus in which the use of inhibited oils can be easily justified; but even in such cases the complication of handling two or more types of oil has been a deterrent. Mixing of inhibited and uninhibited oils does not solve the problem completely, for as shown previously, much of the advantage of the inhibitor is lost in such mixtures, especially in regard to sludging characteristics. Thus, as far as the electrical manufacturer is concerned, at least, it seems that when and if a shift to inhibited oils is made, it is desirable to make it on a "100 per cent basis." This means that some very conclusive evidence in favor of inhibited oils determined in modern apparatus must be available before such a sweeping change away from conventional oil can be made. How soon this matter can be decided will depend largely on how rapidly field experience with inhibited oils can be accumulated on which reliable estimates of their merit can be based.

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DISCUSSION

Mr. C. P. Xenis.[1]—Mr. Berberich, in mentioning the economics of inhibitors, referred to the increase in the cost of the oil when inhibitors are added. The figure he mentioned is about 10 to 100 per cent increase.

In considering the economics of

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such a problem, I think we ought to keep in mind the user of the equipment. When equipment is installed in a system with transformers all over the area, the cost of replacing oil in transformers and the cost of making the tests to follow up the acidity of the oil, represent an appreciable item. I think that this item of cost should be kept in mind, namely, the cost of following up the oil acidity as well as making the replacements of oil in small amounts, in various locations on the system.

It was mentioned that modern transformers with welded covers, solder sealed bushings and other enclosures, may not require inhibitors. I think that is quite so. On the other hand, we should keep in mind the thousands of transformers on the system which have been manufactured for many years, which have gasketed covers. Anything that can be done to prolong the life of the oil in that type of a transformer is still of great importance to the user.

The comment has been made that oil in a transformer usually lasts approximately eight years or so. While this figure may be pretty good for gasketed transformers, in the case of transformers with welded covers and solder sealed bushings, the figure is very low. In this case the life may be 16 yr. or longer.

MR. R. G. LARSEN.[2]—I should like to ask Mr. Berberich a question with regard to the secondary uses of transformer oils, namely, which are the most important uses to which transformer oils are put in addition to use in transformers. Would that be in switch oils or in some other type of electrical equipment?

MR. LEO J. BERBERICH (*author*).—I think as far as volume is concerned, it would most certainly be switch oils, and then oil for capacitor and bushing impregnation would be next.

I should like to ask you, or anyone else who cares to answer, a question regarding the interfacial tension test. I have not been following this test myself, so I do not know much about it. As I see it, almost anything that happens to oil should decrease its interfacial tension, and I have heard it said that the interfacial tension will actually enable the prediction of the life of the oil or the prediction of the time when the acidity is going to start increasing, or when sludge is going to form, and so on. I notice from the data in your paper, that the curves of acidity and the oxygen absorption start to increase at exactly the same time as that at which the interfacial tension comes down. I wonder what the nature of this anticipatory feature is supposed to be.

MR. LARSEN.—I am not an expert on interfacial tension. Others here can better answer it than I. Reading the literature on the subject, it seems that in the beginning the interfacial tension of a new oil is quite high, say, in the order of fifty dynes per centimeter. When it gets down to twenty, or a little below perhaps, then they feel that the point has been reached where sludges will begin to settle out. That might be true for conventional oil; again, it may not be true for a more highly acid treated oil. So I think it is just a generalization applying to oils which they are dealing with. It is probably true that once an inhibitor is exhausted you will notice a break in the interfacial tension curve. As I showed in Fig. 6 of my paper, the serious break came around an interfacial tension of thirty dynes. The drop which occurred during the induction period was less severe and values stayed above the value of thirty during the whole time.

In other words, had I not had a way to measure the oxygen absorption of the oil, I could have described from the complete interfacial tension curve just about what was going on. However, you could not predict ahead of time by looking at the curve how long the inhibitor would last and I think that is probably where the thing would fall down when applied to inhibited oil.

MR. E. F. WALSH.[3]—Mr. Berberich has presented a very interesting paper on oil technology and the effects of oxidation inhibitors in insulating oils.

The curves shown in Figs. 6, 8, and 9 in his paper are carried far beyond the time period oils would actually be serviceable in equipment. For all practical purposes, an oxidation inhibited oil would not be used beyond its so-called induction period. During this period no detectable change in neutralization number would be apparent and by laboratory and field tests this period exceeds by many times the normal life of an uninhibited oil. The neutralization number therefore cannot be used as a measure of the expended life of an oxidation inhibited insulating oil during its induction period. However, the interfacial tension test will indicate the rate of inhibitor consumption and can be used to predict when the inhibitor will be consumed. These statements refer to oils which have been properly refined and inhibited for maximum stability.

MR. BERBERICH.—I did not wish to detract from the value of a very fine test. I am perfectly in agreement that it is a very simple test to make. The apparatus is cheap and the skill required to perform the test is not very high. Therefore, it has all the attributes desired in a test for use in following the behavior of oils in transformers. But I am still wondering why you could not do almost the same thing by following the acidity which I will grant takes longer to carry out, and perhaps requires more skill. The acidity test would tell you more, I think, because in the end you want to know whether the oil is acid, or does it contain sludge and how much of each? The main thing in favor of the interfacial tension test as I see it, is that it is so simple and it does almost the same thing as some more complicated tests.

MR. WALSH.—As previously stated, the neutralization number apparently does not indicate a change in an inhibited oil in service until approximately 80 per cent of its nonsludging life has been consumed.

It is recognized that the interfacial tension test is not sensitive beyond the state when insoluble sludge begins to form, but when an oil reaches this condition it should be replaced and a record of how much sludge is forming does not appear to be of any significance.

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Power Factor of Insulating Oils, Its Significance and Methods of Testing Stability

By J. C. Balsbaugh[1]

THE power factor of an electrical insulating oil has been used for a long time as one of the important criteria of quality of the oil. Power factor has been variously defined in terms of the cosine of the angle between voltage and current, the ratio of the in-phase component to the quadrature component of current, or the ratio of the watts loss to the charging volt-amperes. Since mineral insulating oil is composed primarily of nonpolar hydrocarbons, the electrical loss in an insulating oil is principally ionic in character. Accordingly the power factor of an oil is directly related to the ionic content of the oil under the conditions of test, and the power factor is the ratio of the ionic component to the capacitance component of current. Since the ions are in most cases oxidation products and are to some extent active chemically, it is this fact that makes the power factor of significance in appraising quality, degree of deterioration, and serviceability.

The significance of the power factor of an insulating oil and the methods of testing power-factor stability are discussed principally from the point of view of laboratory tests and an analysis of the mechanisms involved. Test results are given on experimental samples rather than commercial insulating oils for the purpose of illustrating various characteristics.

Effect of Power Factor on Load Ratings:

Electrical insulating oils are used in oil-impregnated paper-insulated cables, condensers, transformers, and other oil-filled or oil-impregnated electrical equipment. In oil-paper cables and condensers the magnitude of the power factor determines the dielectric losses and these may be significant in determining load ratings and heating limitations. Table I gives load ratings, maximum allowable copper temperatures, conductor losses at the load ratings, and the dielectric loss for a 1 per cent power factor of the oil-paper insulation. The permissible load rating of a cable is determined primarily by the resistance losses in the conductor due to the conductor current and the dielectric losses due to the dielectric power factor that produce the allowable copper temperature. The data in Table I give representative cases in the voltage range from 15 to 69 kv. for both three-conductor shielded and single-conductor oil-impregnated paper-insulated cables for certain average conductor sizes. For these representative conductor sizes a 1 per cent power factor of the oil-paper insulation gives a dielectric loss of 1 to 10 per cent of the conductor loss at the load rating. For any other dielectric power factor greater than 1 per cent, the ratio of the dielectric losses to the conductor losses will be increased proportionately. Thus the dielectric losses are quite significant in determining the permissible load that the cable can carry, and any substantial increase in power factor of the oil-paper will reduce the allowable load that the cable can carry. The economic cost on an annual or capital basis of an increase in power factor can be calculated readily from the proportionate loss in rating and the total cost of the cable and accessories and from the energy cost of the added dielectric loss itself.

Power-Factor Stability Under Oxidation:

Electrical insulating oils in service applications are subject to restricted oxidation in the presence of various contact materials. Accordingly, it has been an established practice for a long period of time to study the change in power factor of an oil when subjected to different oxidation conditions at operating or higher temperatures. It is desirable to have an oil which shows a minimum rate of change in power factor when subjected to accelerated aging tests due to various oxidation conditions with and without different contact materials and voltage stress that may represent service conditions.

The most common test condition is represented by accelerated aging of the oil in open containers or in a closed system with oxygen continuously made available to the oil. These tests may be run at temperatures in the range from 85 to 125 C. At periodic intervals the power factor of the oil is measured. Contact material such as paper, copper, lead, iron, or other contact materials encountered in service are placed in the oil. The principal difference between the closed and open systems

TABLE I.

	Three-Conductor shielded 350,000 cir. mils Sector, Paper, Lead Sheath	Single-Conductor 1000 cir. mils, Standard Concentric, Paper, Lead Sheath Open Sheath Operation			
(1) Kilovolt rating, grounded neutral	15	35	15	35	69
(2) Insulation thickness, mils	203	375	203	375	688
(3) Charging Kva., 3φ, per mile	70	220	97	330	820
(4) Maximum allowable copper temperature, deg. Cent.	81	70	81	70	60
(5) Current rating, amp. per conductor	293	264	782	798	592
(6) Load rating, Kva. 3φ, per circuit	7800	16 000	20 000	42 000	70 000
(7) Conductor loss, kw. 3φ, per circuit per mile	55	42	131	105	73
(8) Dielectric loss, kw. 3φ, per circuit per mile for 1 per cent power factor	0.70	2.2	0.97	3.3	8.2
(9) Ratio per cent, dielectric loss to conductor loss, per cent (8)/(7)	1.3	5.2	0.74	3.1	11

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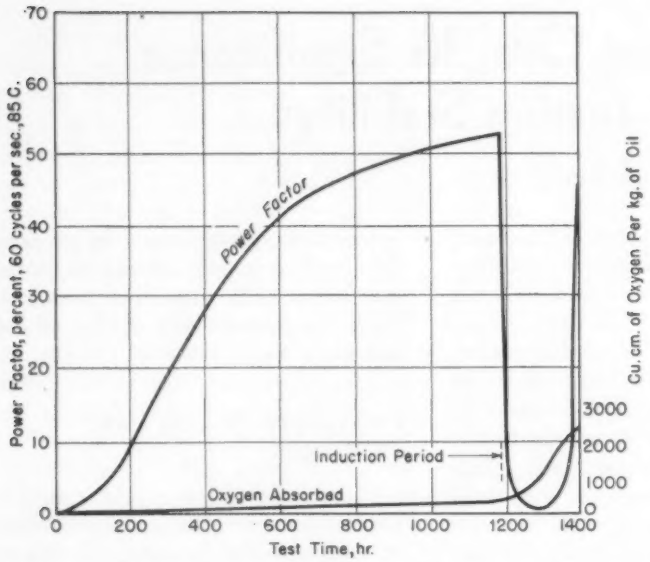
Power Factor, percent, 60 cycles per sec., 85 C.
Cu. cm. of Oxygen Per kg. of Oil
Power Factor
Induction Period
Oxygen Absorbed
Test Time, hr.

Fig. 1.—Hexadecane—Continuous Oxidation—Test Run and Power Factor Measured at 85 C.—Copper 1.6 sq. cm. per Gram of Oil—Power Factor at Frequency of 60 Cycles per second.

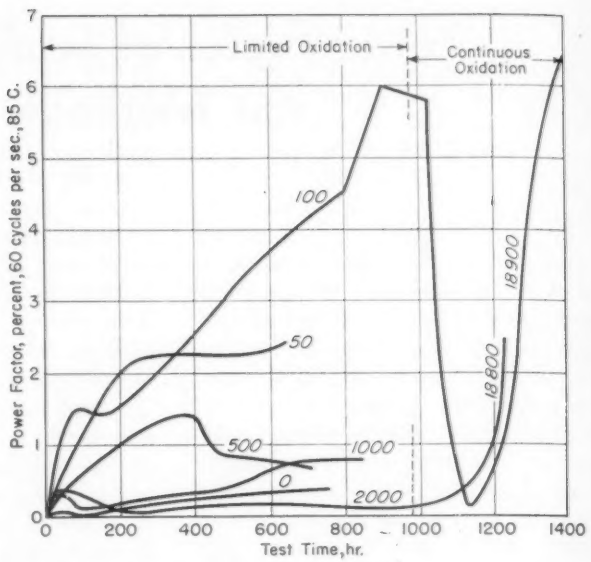

Fig. 2.—Experimental Oil—Continuous and Limited Oxidation—Test Run and Power Factor Measured at 85 C.—Copper 1.6 sq. cm. per Gram of Oil—Power Factor at Frequency of 60 Cycles per Second—Values on Limited Oxidation Curves Indicate Cubic Centimeters per Kilogram of Oil—Values on Continuous Oxidation Curves Indicate Cubic Centimeters of Oxygen per Kilogram of Oil Absorbed at End of Test.

is the retention of volatile oxidation products with the closed system.

In certain applications such as oil - impregnated paper - insulated cables, the amount of oxygen available to the oil in service is very small or negligible. However, even in such cases, tests on sealed cable sections at elevated temperatures have shown significant increases in the power factor of the oil. Consequently power-factor stability tests of an oil under limited oxidation conditions in a closed system in which only residual or relatively small amounts of oxygen are made available to the oil are important. In these limited oxidation tests, contact materials are used similar to those used for the continuous oxidation tests.

Representative power-factor stability tests under various oxidation conditions on experimental oils are shown in Figs. 1, 2, and 3. Figure 1 gives the power factor, at a frequency of 60 cps. and at the test temperature of 85 C., as a function of time under continuous oxidation conditions in a closed system with copper for the normal paraffin, hexadecane. This hydrocarbon produces very interesting electrical results in view of the oxidation characteristics of this oil. The rate of oxygen absorption as a function of time is also shown in Fig. 1. It may be noted that at the oxidation temperature of 85 C., the initial oxygen absorption is approximately linear for an amount of 500 cu. cm. of oxygen per kilogram of oil over a period of 1200 hr. During this period of very low oxygen absorption, the power factor rises very rapidly, reaching a maximum value of approximately 50 per cent. At the end of this period of low oxygen-absorption rate, usually referred to as the induction period, the rate of oxygen absorption increases very markedly, and simultaneously the power factor drops from a value of approximately 50 to 0.1 per cent. With continued oxygen absorption the power factor again rises to a value again approximating 50 per cent. It is believed that during the induction period, intermediate oxidation products and copper - organo compounds are formed which produce the very high losses for relatively small amounts of oxygen. At the end of the induction period, the oxidation proceeds to the normal end products such as acids and water with substantially lower power factor. These test results for hexadecane are shown because they indicate both limited and continuous oxidation characteristics. These results are obtained due to inherent oxidation characteristics of this compound. The induction period represents a limited oxidation condition. Identical results may be obtained with this hydrocarbon in which limited amounts of oxygen are made available instead of the excess amounts as in this test. Of course in such a limited oxidation test the power factor would remain at the high value and would only decrease for the condition of additional amounts of oxygen being made available corresponding to the end of the induction period in Fig. 1.

Figure 2 illustrates both limited oxidation and continuous oxidation tests on an experimental oil produced by heavy refining of a petroleum crude oil. This test was made at a temperature of 85 C. with copper in contact with the oil, the copper being in the form of small copper wire having a surface area equal to 1.6 sq. cm. of copper per gram of oil. In this test different samples were run under limited oxidation conditions of 0, 50, 100, 500, 1000, and 2000 cu. cm. of oxygen per kilogram of oil made available to the oil. At the end of approximately 1000 hr., in the case of the 100 and 2000 limited oxidation tests, the tests were changed to the continuous oxidation type. These results are interesting in that for the limited oxidation conditions, the highest power factors were obtained

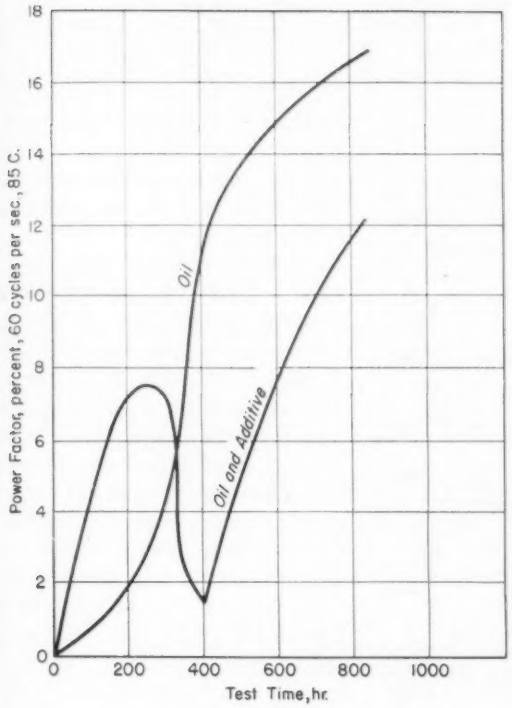

Fig. 3.—Experimental Oil Alone and with 0.13 per cent of 2,6 Di-tert-butyl-4-methylphenol—Continuous Oxidation Test and Power Factor Measured at 85 C.—Copper 1.6 sq. cm. per Gram of Oil—Power Factor at Frequency of 60 Cycles per Second.

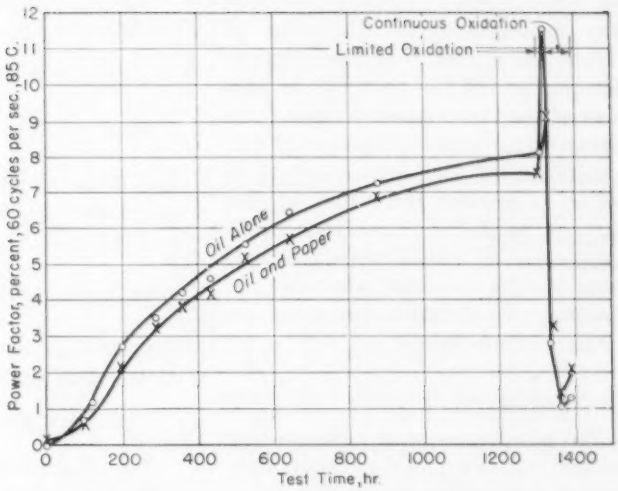

Fig. 4.—Experimental Oil—Limited and Continuous Oxidation—Oxidation and Power-Factor Measurements at 85 C.—Limited Oxidation 500 cu. cm., Oxygen per Kilogram of Oil—Oxygen Absorption at End of Continuous Oxidation, 10,000 cu. cm. Oxygen per Kilogram of Oil—Power Factor Measurements at Frequency of 60 Cycles per Second on Both Oil Alone and Oil-Paper.

with 100 cu. cm. of oxygen per kilogram of oil. For the limited oxidation test using 100 cu. cm. of oxygen per kilogram of oil, the power factor increased to a value of about 6 per cent at the end of the limited test of approximately 1000 hr. With the transition to a continuous type of oxidation, the power factor decreased rapidly to 0.1 per cent and then with increased oxygen absorption the power factor again increased to approximately 7 per cent after a total oxygen absorption of 18,900 cu. cm. of oxygen per kilogram of oil. These results indicate an oxidation mechanism somewhat similar to that for hexadecane as shown in Fig. 1 and described previously. However, in this case the sample under continuous oxidation conditions does not have an induction period and the power-factor characteristics under continuous oxidation are somewhat similar to those of Fig. 1 following the induction period. Thus it is presumed that under continuous oxidation the oxidation proceeds to the normal end products. In this type of an experimental oil, the limited oxidation characteristics must be forced or obtained through restricted amounts of oxygen being made available to the oil in a closed system.

Figure 3 indicates the power factor as a function of time for another experimental oil, with and without an additive, under continuous oxidation conditions at a test temperature of 85 C. and with copper as a contact material in the amount of 1.6 sq. cm. of area per gram of oil. The additive is 0.3 per cent of 2,6 di-tert-butyl-4-methyl-phenol. The power factor is of interest in this case since it shows quite closely the effect of the additive. For the case of no additive, the oxidation is of the uninhibited type and the power factor is relatively low in terms of oxygen absorption. The oxygen absorption is approximately 2000 cu. cm. of oxygen per kilogram of oil at the end of 200 hr. of the test and approximately 4000 cu. cm. of oxygen per kilogram at the end of 800 hr. or the conclusion of the test. With the additive, the oxidation reaction is of the inhibited type and corresponds to a forced limited oxidation. For the initial 200 hr. of the test, the oxygen absorption is approximately 300 cu. cm. of oxygen per kilogram of oil and increasing to approximately 2000 cu. cm. of oxygen per kilogram of oil at the conclusion of the test. It may be noted, that, similar to the experimental oils previously described, this oil gives relatively high power factors during the limited oxidation conditions which decrease to much lower values when the change is made to the continuous oxidation type. Furthermore, in this case the power factor as a function of time or additional oxygen absorbed is the same for the oil with the additive at the conclusion of the induction period as for the sample without any additive. Thus the additive has merely served to restrain oxygen absorption and the subsequent development of products leading to high power factor.

Figure 4 gives the results of another experimental oil with an initial limited oxidation condition for a period of approximately 1300 hr. of test and at this point a transition to a continuous oxidation. This test is run at a temperature of 85 C., with electrical measurements made at this temperature, on both the oil and an oil-paper cell. The results show that during the limited oxidation conditions of the test, the oil power factor is greater than that of the oil-paper. The paper used is Whatman's 41-H ashless filter paper. At the conclusion of the limited oxidation, the power factor of the oil and oil-paper increases markedly with additional available oxygen and then decreases to significantly lower values. This initial increase in power factor at the transition to

the continuous oxidation is probably associated with the rate at which oxygen is absorbed during this portion of the test. It is also interesting to observe that the power factor of the oil-paper at the conclusion of the continuous oxidation is greater than that of the oil. As will be discussed more completely in a subsequent section, these results indicate selective absorption of oxidation products by the paper from the oil.

Electrical Measurements:

The admittance y of a dissipative circuit consisting of parallel conductance g, and susceptance b is

$$y = g + jb = j\omega C_o\epsilon = \omega C_o(\epsilon'' + j\epsilon') \text{ (mhos)} \quad (1)$$

in which

$\epsilon = \epsilon' - j\epsilon''$,
C_o is the geometric vacuum capacitance of electrode arrangement, farads,
$\omega = 2\pi f$,
f is the frequency in cycles per second,
$b = j\omega C$, and
C is the capacitance of the electrode arrangement including the dielectric, farads.

The dielectric constant ϵ' of the dielectric is given by

$$\epsilon' = \frac{C}{C_o} \text{ numeric} \quad (2)$$

The conductance g of the dielectric is given by

$$g = \omega C_o\epsilon'' \text{ (mhos)} \quad (3)$$

Since $C_o = 0.0885 \frac{S}{A} (10^{-12})$ farads in which S and A are the electrode spacing in centimeters and the electrode area in square centimeters, respectively; $g = g_s\frac{A}{S}$; the specific conductance g_s of the dielectric is given by

$$g_s = 0.556(10^{-12})\epsilon''f \text{ (mho cm.)} \quad (4)$$

The dissipation factor, d, of the dielectric is given by

$$d = \tan\delta = \frac{g}{\omega C} = \frac{g}{\omega C_o\epsilon'} = \frac{\epsilon''}{\epsilon'} \text{ (per unit) (numeric)} \quad (5)$$

The loss factor ϵ'' is given by

$$\epsilon'' = \epsilon' \tan\delta = \epsilon'' d \quad (6)$$

The power factor, p, of the dielectric is given by

$$p = \cos\theta = \cos(90 - \delta) = \sin\delta \text{ (per unit) (numeric)} \quad (7)$$

The power loss P in the dielectric, with effective voltage E in volts and effective current I in amperes, is

$$P = E^2g = EI\cos\theta = EI\sin\delta = E^2(2\pi C_o)\epsilon''f \text{ (watts)} \quad (8)$$

The conductance factor of the dielectric is given by $\epsilon''f$.

Ionic and Dipole Losses:

Many insulating oils have relatively small nonhydrocarbon components, such as sulfur components. The contribution to the conductivity or power factor of the oil due to both the ionic and the dipole type of losses can be determined by making measurements over a wide range of frequencies and temperatures. Such measurements are indicated in Figs. 5 and 6 which give loss factor ϵ'' as a function of frequency for different temperatures as given on the curves at which the power factor measurements were made. The results in Fig. 5 have been obtained with an experimental oil, having a viscosity in the transformer oil range, following a limited oxidation test at 85 C., 0 cu. cm. of oxygen per kilogram of oil, 1.6 sq. cm. of lead surface per gram of oil, with the measurements being made at the end of 385 hr. of the test. Figure 6 gives corresponding results for the same oil with the addition of 0.1 per cent cetyl mercaptan, following a limited oxidation test at 85 C., 100 cu. cm. of oxygen per kilogram of oil, 16 sq. cm. of copper surface per gram of

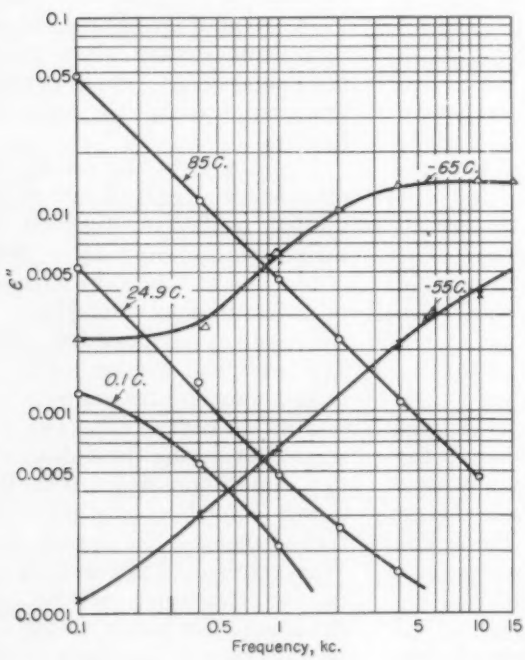

Fig. 5.—Experimental Oil—Loss Factor ϵ'' as a Function of Frequency—Power Factor Measurements Made Following Limited Oxidation Test, 0 cu. cm. of Oxygen per Kilogram of Oil, 85 C., 1.6 sq. cm. of Copper per Gram of Oil, Test Run 385 hr.

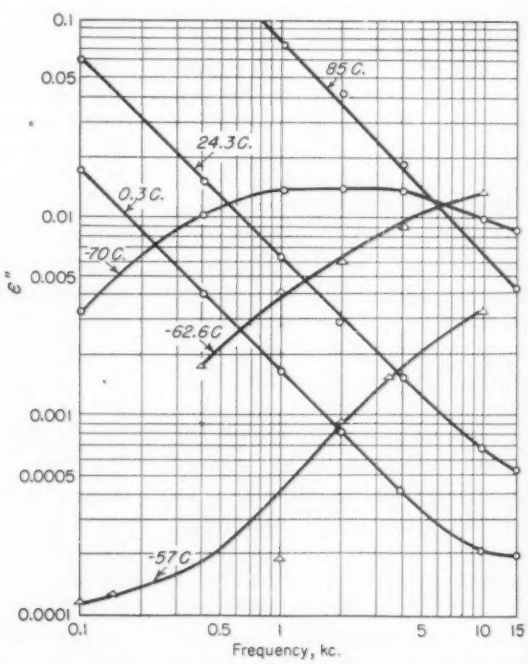

Fig. 6.—Experimental Oil with Addition of 0.1 per cent Cetyl Mercaptan—Loss Factor ϵ'' as a Function of Frequency—Power Factor Measurements Made Following Limited Oxidation Test, 100 cu. cm. of Oxygen per Kilogram of Oil, 85 C., 16 sq. cm. of Copper per Gram of Oil, Test Run 648 hr.

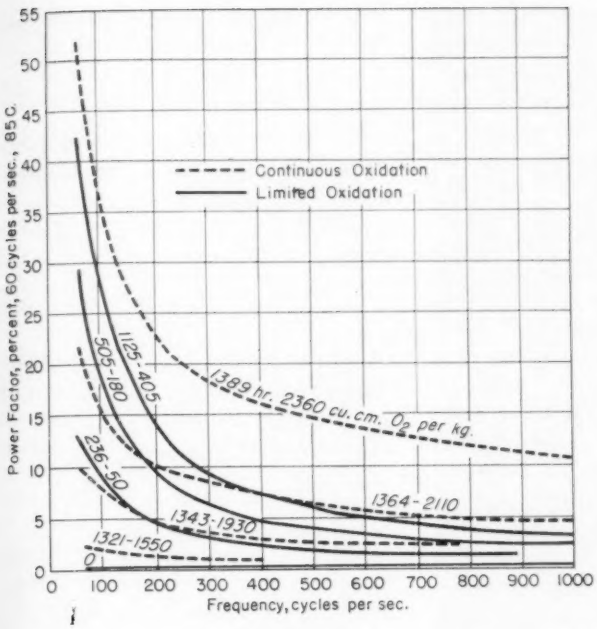

Fig. 7.—Hexadecane—Continuous Oxidation, 85 C., Copper 1.6 sq. cm. of Oxygen per Gram of Oil—Power Factor as a Function of Frequency—Power-Factor Measurements Made on Oil-Paper Sample at Oxidation Time in Hours and Oxygen Absorption as Indicated.

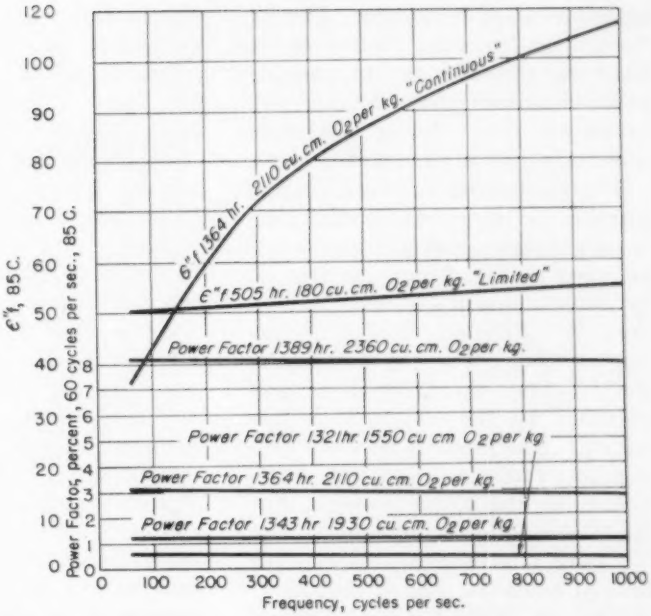
ε"f, 85 C.
Power Factor, percent, 60 cycles per sec., 85 C.
Frequency, cycles per sec.
ε"f 1364 hr. 2110 cu. cm. O2 per kg. "Continuous"
ε"f 505 hr. 180 cu. cm. O2 per kg. "Limited"
Power Factor 1389 hr. 2360 cu. cm. O2 per kg.
Power Factor 1321 hr 1550 cu cm O2 per kg
Power Factor 1364 hr. 2110 cu. cm. O2 per kg.
Power Factor 1343 hr 1930 cu. cm. O2 per kg.

Fig. 8.—Hexadecane—Continuous Oxidation, 85 C., Copper 1.6 sq. cm. of Oxygen per Gram of Oil—Power Factor and Conductance as a Function of Frequency—Conductance $\epsilon''f$ of Oil-Paper for Both Limited and Continuous Periods of Test—Power Factor of Paper Itself Obtained from Equivalent Conductance Attributable to Paper Itself.

oil with the measurements being made at the end of 648 hr. of test. At the elevated temperature of 85 C., the loss factor ϵ'' varies inversely with frequency. Since the conductivity of the oil is proportional to $\epsilon''f$, the conductivity at the elevated temperature is independent of frequency, thus indicating that the losses are of ionic type. This is true of both oils even though the relative power factors are very different. Even at 0 C. the conductivity is practically independent of frequency over the audio-frequency range. With low temperatures in the range of −60 to −70 C., the loss characteristics are of the dipole type. While certain types of hydrocarbon do have structures that give dipole moments, the relative values of these moments and their amounts are such as to lead to the conclusion that most of the dipole type of loss is due to nonhydrocarbon compounds in the oil. This procedure might be an effective means for the evaluation of the amounts and types of such nonhydrocarbon components. Studies on electricali nsulating oils covering a very wide range of properties have generally indicated that in the operating temperature range most of the electrical loss is of the ionic type. Accordingly, the conductivity or power factor will be influenced by the viscosity of the oil. With the electrical loss of the ionic type, the power factor will vary inversely with frequency, since the ionic component of current is independent of frequency and the capacitance component of current increases linearly with frequency.

Analysis of Power Factor of Oil-Paper as Influenced by Oxidation Conditions:

In commercial application, electrical insulating oils are in most cases used in combination with other dielectric materials. Accordingly, it is desirable to study the performance not only of the oil, but of the impregnated material under various oxidation conditions. As previously discussed, the limited and continuous oxidation characteristics of hexadecane gave such contrasting characteristics that this hydrocarbon was also studied with oil-paper in combination. In this test, electrical measurements were made on both the oil and an impregnated-oil-paper sample during the oxidation. The hexadecane was oxidized under continuous oxidation conditions at a test temperature of 85 C. with 1.6 sq. cm. of copper area per gram of oil. The paper used was Whatman's 41-H ashless filter paper. In general, the presence of paper in experimental studies of oil oxidation did not significantly change the oxidation mechanism.

Power-factor measurements of the oil-impregnated paper cell during the oxidation of hexadecane are given in Figs. 7 and 8. Figure 7 shows the power factor in per cent as a function of frequency at different stages during the test. The first number on the curves indicates oxidation or test time in hours and the second number the total oxygen absorption in cubic centimeters of oxygen per kilogram of oil at this time of the test. Similar to the power factor of the hydrocarbon as a function of oxidation time as given in Fig. 1, the power factor of the oil-paper increases very markedly during the limited oxidation conditions, or induction period, of the test. The transfer from the limited (1125–405) to continuous (1321–1550) type of oxidation is accompanied by greatly decreased power factors. Continued oxygen absorption (1321–1550 to 1389–2360) again gives relatively high power factors. Thus the oil-paper combination exhibits the same general range of power factor that was previously shown for the oil itself. In general, the power factor of the oil-paper decreases rather rapidly

with increasing frequency. During the limited oxidation portion of the test, the power factor of the oil-paper decreases more rapidly with frequency than during the continuous oxidation period of the test.

The mechanism of the oxidation reaction as indicated by the electrical measurements of the oil-paper as given in Fig. 7 may be studied by determining the change in conductivity of the oil-paper as a function of time. The conductivity of the oil-paper combination is proportional to the conductance factor $\epsilon'' f$. The relation between conductance factor as a function of frequency for the different stages during the oxidation is indicated in Fig. 8. It may be noted that during the limited oxidation period (505 hr.—180 cu. cm. of oxygen per kilogram) the conductivity is nearly independent of frequency. This characteristic persists throughout the complete limited oxidation period. At the end of the induction period and during the continuous oxidation period of the sample, the conductivity of the oil-paper shows a rapidly increasing value with frequency (1364 hr.—2110 cu. cm. of oxygen per kilogram).

The foregoing results indicate that during the induction period, or limited oxidation, the oil-paper combination merely exhibits the increasing conductivity of the oil itself. Furthermore, the conductivity of the paper itself is practically constant throughout the full range of the limited oxidation, thus indicating that there is no selective absorption by the paper of any of the intermediate oxidation products formed during this period. However, following the induction period, the increase of conductivity with frequency indicates that the paper is selectively absorbing oxidation products and that the paper and oil individually have different loss mechanisms. The results obtained can be accounted for by the paper absorbing from the oil such end oxidation products as acids and water.

If the conductance of the oil-paper combination, as given in Fig. 8, is determined by extrapolation for zero frequency and subtracted from the total conductance at any frequency, the contribution of the paper itself may be obtained. If this is done for the conductance of the oil-paper during the limited oxidation period, negligible amounts are obtained for the paper itself and are practically the amounts obtained at the start of the test for the dry paper and the low-loss hydrocarbon. If the same procedure is used for the conductance of the oil-paper combination during the continuous oxidation period of the test, and the conductance factor obtained attributable to the paper is converted to an equivalent power factor at the given frequency, the set of power-factor curves shown in Fig. 8 is obtained. These show that the power factor of the paper itself, due to absorbed oxidation products, is practically independent of frequency and increases with time during the continuous oxidation period.

Analysis of Dissipation Factor of Oil-Paper in Terms of Dissipation Factors of the Components:

The foregoing indicates that the electrical measurements of the oil and oil-paper combination may be used to study the mechanism of oxidation. Accordingly, it is desirable to be able to determine the dissipation factor of an oil-paper combination from the constants pertaining to the oil and to the paper individually. While the method developed is not applicable in general, it has been useful in certain applications. Assuming a composite dielectric consisting of two individual dielectrics in series, the following applies:

Let

- d_{om} be the dissipation factor (per unit) of oil and associated dielectric material,
- ϵ'_{om} be the dielectric constant of oil and associated dielectric material,
- d_o be the dissipation factor of the oil,
- d_m be the dissipation factor of the associated dielectric material,
- ϵ'_o be the dielectric constant of the oil,
- ϵ'_m be the dielectric constant of the associated dielectric material,
- v_o be the per-unit proportion of the total volume occupied by the oil, and
- v_m be the per-unit proportion of the total volume occupied by the associated dielectric material

Then

$$\epsilon'_{om} = \frac{\epsilon'_m \epsilon'_o}{v_o \epsilon'_m + v_m \epsilon'_o} \quad \ldots\ldots (9)$$

$$d_{om} = \frac{d_o v_o \epsilon'_m + d_m v_m \epsilon'_o}{v_o \epsilon'_m + v_m \epsilon'_o} \quad \ldots\ldots (10)$$

For the condition of unimpregnated material, that is, air in place of oil, the dielectric constant ϵ'_{om} in Eq. 9 becomes ϵ'_{am} for $\epsilon'_o = 1$. This gives

$$\epsilon'_{am} = \frac{\epsilon'_m}{v_o \epsilon'_m + v_m} \quad \ldots\ldots (11)$$

and the increase in capacitance through oil impregnation is given by the ratio of the dielectric constants ϵ'_{om} in Eq. 9 to ϵ'_{am} in Eq. 11 as

$$\frac{\epsilon'_{om}}{\epsilon'_{am}} = \epsilon'_o \frac{v_m + v_o \epsilon'_m}{v_m \epsilon'_o + v_o \epsilon'_m} \quad \ldots\ldots (12)$$

For the condition of unimpregnated material, that is, air in place of oil, the dissipation factor d_{om} in Eq. 10 becomes d_{am} for $d_o = 0$ and $\epsilon_o' = 1$. This gives

$$d_{am} = \frac{d_m v_m}{v_o \epsilon'_m + v_m} \quad \ldots\ldots (13)$$

and for the limiting case of the impregnated material with the dissipation factor d_o of the oil being negligibly small or zero, d_{om} from Eq. 10 becomes for, $d_o = 0$.

$$d_{om} = \frac{d_m v_m \epsilon'_o}{v_o \epsilon'_m + v_m \epsilon'_o} \quad (d_o = 0) \ldots (14)$$

The ratio of the dissipation factor of the impregnated material with impregnant of negligible dissipation factor to the dissipation factor of the unimpregnated material may be obtained from Eqs. 14 and 13. This gives the same result as the ratio of the dielectric constants under similar conditions as given by Eq. 12.

$$(\text{for } d_o = 0) \frac{d_{om}}{d_{am}} = \epsilon'_o \frac{v_m + v_o \epsilon'_m}{v_m \epsilon'_o + v_o \epsilon'_m} \ldots (15)$$

The ratio of the dissipation factor of the impregnated material with impregnant of dissipation factor d_o, to that of the impregnated material with negligible dissipation factor, $d_o = 0$, may be obtained from Eqs. 10 and 14. This gives

$$\frac{d_{om}\ (\text{oil dissipation factor } d_o)}{d_{om}\ (\text{oil dissipation factor } d_o = 0)} = \frac{p_o v_o \epsilon'_m}{p_m v_m \epsilon'_o} + 1 \quad \ldots\ldots (16)$$

An example of the application of the foregoing for representative average values of constants pertaining to oil and to paper individually is given in Table II. It

must be understood that there are definite limitations to the use of the analysis of the component losses in a composite dielectric due to the restrictions placed upon the motion of the ions. However, it is believed that, subject to these limitations, the method is useful in analysis and interpretation of the characteristics of oil-impregnated or oil-filled apparatus under service conditions.

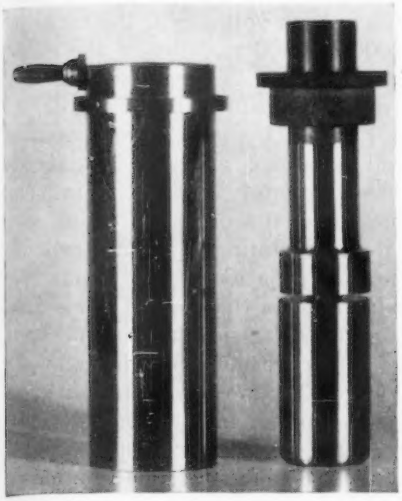

Fig. 9.—Metal Cell for Power-Factor Measurements—Three-Terminal Type.

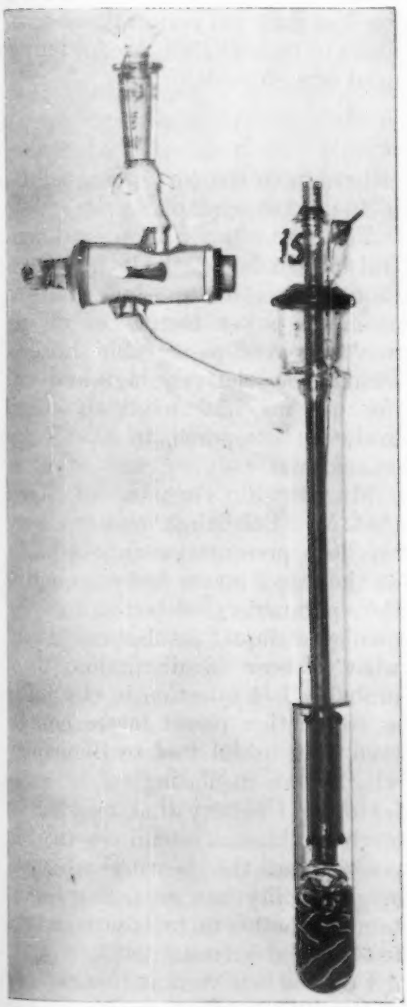

Fig. 10.—Platinum Electrode, Glass Cell for Power-Factor Measurements—Three-Terminal Type.

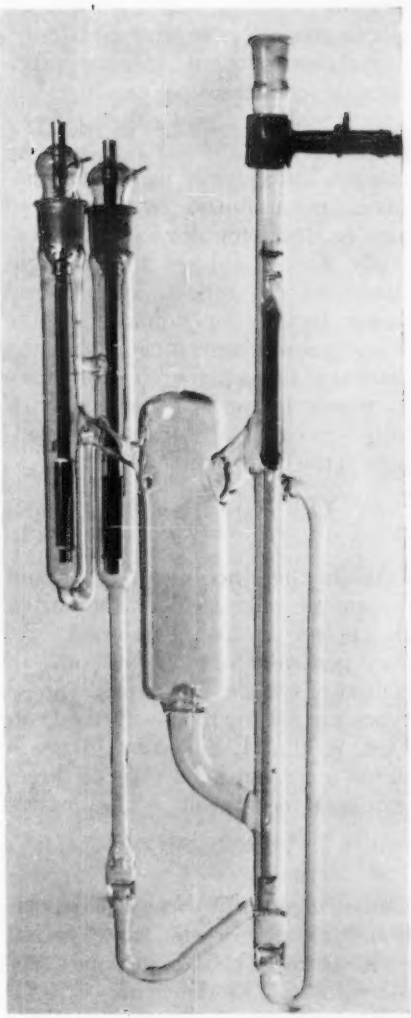

Fig. 11.—Deterioration Cell for Limited or Continuous Oxidation—Electrical Measurements Made on Oil and Oil-Paper in Cells Included in System.

TABLE II

Assume $\epsilon'_m = 6$, $\epsilon'_o = 2.2$, $v_o = 0.4$, $v_m = 0.6$, $d_m = 0.0085$

Dissipation factor of the unimpregnated paper (Eq. 13) $d_{am} = 0.0017$.

Dissipation factor of the impregnated paper with oil of negligible dissipation factor $d_o = 0$ (Eq. 14) $d_{om} = 0.003$.

Dielectric constant of the unimpregnated paper (Eq. 11) $\epsilon'_{am} = 2$.

Dielectric constant of the impregnated paper (Eq. 9) $\epsilon'_{om} = 3.55$.

Ratio of dielectric constants and of dissipation factor ($d_o = 0$) for impregnated to unimpregnated paper (Eq. 12) and (Eq. 15).

$$\frac{\epsilon'_{om}}{\epsilon'_{am}} = \frac{d_{om}}{d_{am}} = \frac{3.55}{2} = \frac{0.003}{0.0017} = 1.78$$

Ratio of dissipation factors of impregnated paper with $d_o = 0.0085$, $d_o = 0.10$, and $d_o = 0.50$ to the dissipation factor of impregnated paper with, $d = 0$ (Eq. 16)

for $d_o = 0.0085$—$d_{om} = 0.0085$
$d_o = 0.10$ —$d_{om} = 0.0678$
$d_o = 0.50$ —$d_{om} = 0.325$

Effect of Corona Discharge on Power Factor of Oil:

In contrast with the oxidation of mineral oils in service application, the deteriorating effect of corona or gaseous electrical discharge is another important factor. In certain types of electrical apparatus operating under high voltage stresses, such as "solid type" cable, the development of low-pressure gas voids is almost inevitable. The increase in power factor of such a cable with increasing voltage is generally attributed to corona. In contrast to a direct quantitative measurement of power factor, the corona characteristics of the cable

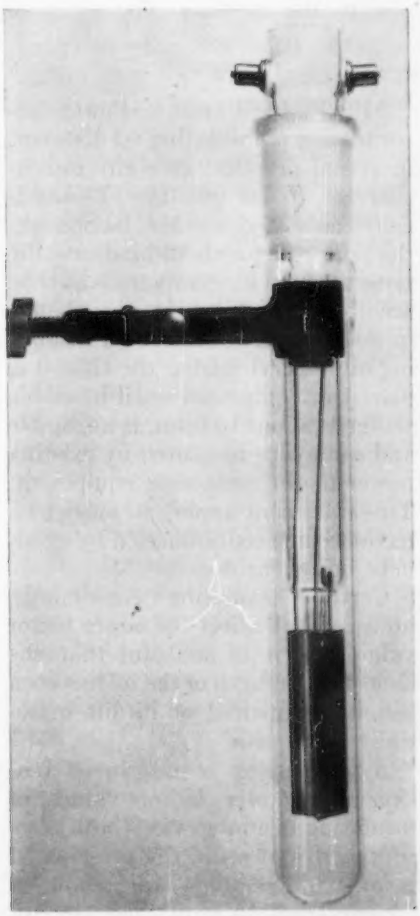

Fig. 12.—Nickel or Platinum Electrode, Glass Cell for Power-Factor Measurements—Two-Terminal Type Using Low-Loss Glass.

or other insulation is probably more effectively studied through the use of a high-pass filter and cathode-ray oscilloscope as used by Quinn, or by a bridge-type of discharge detector as used by Greenfield. While corona-detecting apparatus has been used principally with the assembled apparatus, it is believed that it would prove equally effective for studying laboratory samples having oxidation products such as water included in the sample. For the latter application, an improved and more sensitive type of detecting apparatus probably would be required.

Since mineral oils in service may be subject to gaseous electrical discharge, it has been common practice to study the effect of electrical discharge on oils in laboratory apparatus. The procedure usually consists of measuring the increase in gas pressure under constant volume or the increase in volume at constant pressure and the resulting increase in power factor of the oil due to the corona. The effect of gaseous discharge on hydrocarbon oils is generally to produce a polymerization without gaseous products or condensation products, in which hydrogen and other gaseous products are produced. These reactions, individually or in combination, are produced by high-speed ions or electronic discharges. Generally, the oil subject to this bombardment will indicate an increased power factor, depending upon the severity and length of time that the discharge takes place. The increase in power factor is generally attributed to colloidally dispersed products in the oil.

Cells for Power-Factor Measurements on Oil:

While there are many types and designs of cells used for measuring the power factor of mineral oils, they generally may be assumed to consist of two distinct types. These types are shown representatively in Figs. 9, 10, 11, and 12. Figure 9 shows a conventional type of three-terminal metal cell. The metals used are generally corrosion-resistant steel, monel, nickel, or plated metal. Figure 10 shows a three-terminal platinum-electrode glass cell. Generally the metallic electrode cells are adaptable for relatively high voltages in the range of 1000 to 3000 v., whereas the glass-containing cells are used in the voltage range of 100 v. or less.

Figure 11 shows a deterioration cell including electrical measuring cells that may be used for making measurements on both the oil and oil-paper during a continuous or limited oxidation type of test. The advantage of this type of cell is that it permits electrical measurements to be made without handling the oil. Figure 12 shows a two-terminal glass cell for power factor measurements on liquid dielectrics. The electrodes for such a cell may be made either of nickel or platinum. While a two-terminal cell will have, in general, certain residual losses, the use of a low-loss glass will permit the residual losses to be negligible, except for the most precise work.

DISCUSSION

MR. E. F. WALSH.[1]—Power factor testing of insulating oil does not, in actual practice, give any indication as to its quality. Theoretically, as stated by Mr. Balsbaugh, the power factor should indicate the presence of polar compounds as they are formed. Actually, the change in power factor value of an insulating oil in service from the time it is placed in equipment until insoluble sludge is about to form, is negligible and cannot be measured by existing power factor measuring equipment. This statement applies to oils which have become contaminated by products of oxidation.

Certain insulating compounds, however, will affect the power factor value, but it is doubtful that the dielectric strength of the oil has been seriously impaired or its life materially shortened.

A comparison of interfacial tension and power factor values of insulating oils in service (both tests supposedly measure the presence of polar compounds) will show a change from 55 dynes per cm. for unused oil to 20 dynes per cm. for a used oil near a state of sludge deposition, whereas for the same period no measurable change in power factor value can be detected.

Power factor is a useful test for indicating the condition of a deteriorated insulating oil, that is, after sludging has occurred.

However, experience indicates that transformers should not contain insulating oil having an interfacial tension value below 18 dynes per cm. which for the present excludes the use of power factor as a criterion for indicating the condition of an insulating oil in service.

MR. J. C. BALSBAUGH (*author*).—I do not believe that there is any general relationship between power factor and interfacial tension. I believe that both values are important in evaluating the qualities of an aged mineral oil. The power factor of a mineral oil is dependent primarily on the ionic content of the oil. A large number of tests over many years on both new and aged mineral oils indicate that the power factor of an oil is due practically entirely to ionic conduction. Accordingly, it would be expected that power factor would bear some relationship to the corrosive qualities of an aged mineral oil.

The power factor of an aged mineral oil can be relatively high even though the oil has not sludged. For example, power factors of oil removed from oil-paper cables in service may be relatively high and still the oil has had relatively small oxidation compared to that from transformer.

MR. E. R. THOMAS.[2]—I think that Mr. Balsbaugh made a very excellent presentation in his paper on the use of power factor as one of the parameters determining the quality of liquid insulation. From what I hear in discussion there probably is a question in our mind as to whether power factor can be used as a useful tool to determine whether an insulating oil is satisfactory. I believe that one has to go back basically and justify in one's mind the bearing which a single quality has regarding ascertaining whether an oil is satisfactory to fulfill a given usage.

I do not believe that there is any question but that power factor

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[2] Test Engineer, Electrical Engineering Dept., Consolidated Edison Co. of New York, Inc., New York, N. Y.

measurement is an excellent research tool to study a specific liquid dielectric under various controlled conditions. However, if power factor alone is taken as a method of test to measure any kind of liquid insulation, whether it be a pure hydrocarbon, or more probably having various contaminations in it, then the numerical values of power factor may be a very questionable yardstick for determining whether that oil will be a satisfactory insulating and cooling medium for the purpose.

MR. BALSBAUGH.—I think that Mr. Thomas has expressed the significance of power factor very appropriately in that it is not the sole criterion of quality of an aged mineral oil, but it is one of our most important standards of quality. There is always a natural attempt to develop one test that might be used as a sole criterion of quality, but I do not believe that this is possible in the case of mineral oils.

MR. R. G. LARSEN.[3]—I should like to ask Mr. Balsbaugh how general this tremendous increase in power factor is which occurs during either the induction period or period of low amounts of oxygen absorption. For example, he mentioned a case with cetane and also a case where it occurred when some inhibitors were added. Is it something we would be likely to run into in the usual development such as I have described on transformer oils, or in the use of ordinary oils?

We had not noticed those increases, but we may have missed them, they apparently come and go and I wondered a little about that.

MR. BALSBAUGH.—It has been my experience in general that most mineral insulating oils exhibit to some extent the increases in power factor as shown for hexadecane. I have always found that the presence of copper and lead is necessary for the oil to show this phenomenon. If I understand Mr. Larsen's tests correctly, I do not believe that he had either of these present in large quantities. I do not know whether iron will show the same characteristics as copper or lead.

If a mineral oil has inherently an induction period, then this increase in power factor will usually be shown in a regular oxidation test. If the oil oxidizes without an induction period, then this large increase in power factor can be obtained only by an oxidation test with restricted amounts of oxygen as in the limited oxidation test.

In view of the foregoing, I believe that these high power factors are due to intermediate oxidation products forming in the oil during early stages of oxidation. It is believed that metal soaps play an important part in these high power factors.

MR. E. M. KIPP.[4]—Mr. Balsbaugh, in your opinion could the abrupt and steep increase in power factor values be used as an end point value with reference to oil quality? Also, have you made any interfacial tension measurements in order to determine whether there is any correlation between your power factor value curves and interfacial tension values?

What I cannot understand is why power factor tells us something that interfacial tension value does not tell as well or better with reference to the chemical condition of the oil.

Speaking as a chemist, the interfacial tension value should be a sensitive tool because any polar compounds in the oil, the minute they are formed even in minute quantities, will concentrate at the interface of the oil and the water. I presume that the polar molecules are the ones that break down the insulating value of the oil. So, therefore, if an interfacial tension test is run, the interfacial tension values, should be affected by the presence of polar molecules even though they are peroxide or copper soaps. Metal soaps should affect the interfacial tension value quite markedly. I do not see where power factor tells you something that interfacial tension does not tell you just as well, and perhaps quicker, with reference to the oxidation of insulating oils.

MR. BALSBAUGH.—I do not believe that the end point values could be used as the sole criterion of oil quality. The tests that I have made probably are more applicable to oil-paper cables than to transformers. Since the power factor of an oil-paper cable may be important in determining permissible load ratings, these increases in power factor are important from the practical point of view.

Interfacial tension measurements have not been made on the oils reported in this paper. I am quite sure that the oils studied are quite far removed from the sludging point.

MR. L. J. BERBERICH.[5]—Commenting on Mr. Balsbaugh's paper, it is agreed that both power factor and interfacial tension should be useful tools as is the case for a number of other tests. With respect to the interfacial tension tests, I would say that almost anything that happens to an oil ought to affect the results you obtain. If you find a decrease in interfacial tension you still are not sure as to what has been going on. To a certain degree that is also true of power factor. But you can find out something by making power factor measurements such as Mr. Balsbaugh has described. For instance, one might analyze the data and obtain some idea of the size and type of polar molecule that is responsible for the power factor, provided the measurements are made over a wide temperature range. This, however, requires considerable effort and equipment.

I should like to ask Mr. Balsbaugh whether there was any evidence of a second phase in the case of the rise of power factor that he has observed in the early stages of oxidation. It is possible that insoluble soaps or whatever is the cause of the rise of power factor may have separated out from the oil. Usually that kind of phenomenon can bring about a very rapid increase in power factor.

MR. BALSBAUGH.—In general we did not observe a second phase during the occurrence of the high power-factor peaks. In certain cases, chemical tests did indicate the presence of copper soaps. Mr. Piper of the Detroit Edison Co. has done a very large amount of work involving the addition of copper soaps to mineral oils. His studies indicate relatively high power factor under certain conditions. It would be of interest to know whether these high power factors are due to the action of certain hydrocarbons in the oils themselves or are due to relatively small amounts of nonhydrocarbon components that are usually present.

[3] Head, Dept. of Lubricants and Gasoline Research, Shell Development Co., Emeryville, Calif.

[4] Chief, Lubricants Div., Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa.

[5] Manager of Physical Section, Insulation Dept. of Westinghouse Research Labs., East Pittsburgh, Pa.

Serviceability Tests on Transformer Oil From the Viewpoint of the Maintenance Engineer

By Frank J. Pohnan[1]

Transformer Oils Are Not Stable:

One of the oldest, yet one of the toughest important problems with which the maintenance engineer responsible for the continuous operation of a power system is faced is the correct determination of the condition and serviceability of insulation of the major, high-voltage equipment connected to the system. Of prime importance among this equipment is the transformer. While the modern, present-day transformer may be taken as an excellent example of reliability of electrical equipment, the majority of transformers in use are of an older type and suffer from almost all of the known forms of insulation deterioration.

It is well known that transformer oils are not stable either electrically or chemically and, when subjected to elevated temperatures and other service conditions, they will change their characteristics, will age and deteriorate. The deterioration is progressive, since its rate increases with time and with the deterioration of the oil.

When a certain degree of deterioration of the oil has been reached, it ceases to fulfill its function as a dielectric and as a cooling medium and may cause a failure of the transformer. In view of this, it is obvious that the maintenance engineer cannot be satisfied merely to start with good new oil having excellent chemical and dielectric properties, but from time to time he must have reliable information as to how much the oil has changed, how far it has deteriorated, and as a consequence of these changes, how much risk is involved in further operation of a transformer.

Some 30 years ago, only two relatively simple tests were customarily made: the breakdown test, which for years was about the only recognized test to determine the dielectric strength of the oil, and the hot poker test to find whether the oil contained any moisture. Since then great progress has been made in view of the attention given to the problem by scientists and engineers.

Oil Oxidation and Resulting Changes:

Deterioration of insulating oils has been the subject of numerous researches and investigations conducted by individuals as well as by committees of our national societies. The attention of the scientists was first directed toward the nature and causes of the deterioration. In the laboratories of universities, oil refineries, and transformer manufacturers, the changes in the chemical composition of the oil resulting from its deterioration were studied and it was found that predominant among the causes of deterioration is oxidation. This oxidation starts immediately after the oil is placed in the transformer, and results in the formation of sludge, organic acids, peroxides, highly conducting metal soaps, water, and other deterioration products. Its first visible sign is a gradual changing in color of the oil. With continued oxidation the deterioration products form more rapidly and the color of the oil becomes progressively darker. The rate of formation of the oxidation products indicates the rate of change of the physical and chemical properties of the oil and their amount shows the degree of its chemical deterioration.

This situation becomes even more involved for the maintenance engineer when he is informed by the scientists that oils are extremely complex substances and contain a great number of individual compounds about some of which only very little is known. He is told that, basically, oils are hydrocarbons, that is, they are composed entirely of hydrogen and carbon, except for some small amounts of incidental impurities which may be present. He is also told that transformer oils are obtained from petroleum by vacuum distillation. Impurities and some of the unsaturated hydrocarbons are removed from the oil by an acid treatment after the distillation. Up to about 10 per cent of the unsaturated hydrocarbons are allowed to remain in the oil because they act as natural inhibitors. All the hydrocarbons are very active materials; they will quite readily unite with oxygen from the air if they are exposed to it.

The reaction between oxygen and oil hydrocarbons results in the production of new compounds, deterioration products, among which aldehydes and acids are predominant. Aldehydes and acids formed during the oxidation of transformer oil unite with themselves, that is, polymerize, and as a rule the larger the new molecule becomes the less soluble it is. When these aldehyde-acid molecules formed by polymerization have grown to comparatively large dimensions they become insoluble in the oil and settle out. In this form the petroleum resin is called sludge.

Since the unsaturated hydrocarbons are known to produce sludge as an end product, the maintenance engineer logically asks the scientist, "Why not remove them in refining?" He is told that this can and has been done and that when it is done we have a so-called over-refined oil. Such an oil is very susceptible to oxidation, and even though practically no sludge is produced, the acidity of the oil reaches a very high value in a short period of time, so high in fact that the oil acids will readily corrode metals, particularly copper, producing metal soaps. These soaps dissolve in the oil with resulting deleterious effects on its electrical characteristics. The unsaturated hydrocarbons have been found to be remarkable natural inhibitors which, by becoming slightly oxidized, considerably retard further oxidation of the oil.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication of for the attention of the author. Address all communications to A. S. T. M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Senior Testing Engineer, Commonwealth Edison Company, Chicago, Ill.

The oxidation of insulating oils does not proceed directly but through the intermediary of catalysts, which first absorb oxygen, form peroxides, and then give up half of the oxygen to the oil.

The work of the scientists has resulted in many new developments and has indeed gone far in explaining the fundamental reasons and processes of deterioration of the oil in service as well as the significance of the chemical changes in the oil resulting from its oxidation. It has advanced our knowledge not only about transformer oils but about transformer insulation as a whole. The scientists have listed for us the desirable properties a good oil should have and those characteristics that may serve as criteria of its quality or condition. They have listed stability during service, and retention of all its desirable chemical and electrical properties over a considerable length of time as the main requirements of any good insulating oil. To determine those properties of oil whose magnitude, or rate of change, may be used as a possible criterion of quality or condition of an oil, they have developed new tests and test methods, designed new, more sensitive instruments and apparatus, and after long and thorough laboratory researches have recommended the following tests: total and water-soluble acidity, color number, ester value, emulsification, hydrophil number, refractive index, sludge formation and accumulation, saponification, dielectric loss, dielectric constant, dielectric strength, power factor, and d-c. resistivity or conductivity. These tests have been generally accepted and are widely used, and many of them are fully described in the A.S.T.M. test methods.

A number of the fundamental investigations and scientific studies of the nature and causes of insulating oil deterioration have been described in the technical literature. Of special interest is a contribution by F. M. Clark,[2] in which he analyzed the various tests now in use on insulating oil and presented a series of relationships between pairs of properties of insulating oil as affected by oxidation.

[2] F. M. Clark, "A Correlation of the Chemical and Electrical Changes Observed During the Oxidation of Mineral Insulating Oil," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1213 (1940).

Condition of Oil and Insulation as Found in Service:

To reduce the probability of transformer failures and to insure continuity of service, probably every power company now has a program for regular inspections of the condition of transformer insulation which includes routine tests on the insulating oils. We have inspected over a period of years the condition of insulation of a great many transformers of various types, makes, sizes, and ages, which were removed from service for various reasons. We found that the oil as a result of its deterioration had become discolored, carried various amounts of sludge, small solid particles and carbon in colloidal suspension and quite often had a moldy odor. Additional sludge in the form of a pasty coating was deposited on the windings, transformer cores, and on the bottom of the tanks. However, the startling result of these investigations was the frequent finding of evidence of deterioration of the solid insulation. This deterioration was manifested chiefly by a great reduction of the mechanical strength of the insulation. It was most apparent in the brittleness and greatly reduced ability of the pressboard to withstand even a slight bending without cracking, in the extremely low tensile strength of the tying cords, in numerous small pieces which had become detached from the main body of the pressboard and in the appearance and physical condition of the cotton covering of the coil conductors. In a number of cases the cotton tape on the coils was stained green in spots, while the cotton insulation on the conductors was of a more or less uniform green color in much larger areas. Upon removal of the cotton insulation, a green corrosion product was found on the surface of the copper conductors directly beneath the discoloration of the cotton covering. The copper itself showed evidence of considerable corrosion. The presence of the green deposit on some of the conductors and in the adjacent insulation suggested the probability of an attack on the copper by organic acids, with the resultant formation of organic copper compounds or copper soaps. Upon dissecting a coil and removing the residual oil with petroleum ether and the varnish constituents with benzol, the green deposit was extracted from the cotton insulation with a suitable solvent for copper soaps (monomethyl ether). An analysis of the soap extracted from this sample showed that it contained about 10 per cent copper. The remainder of the extraction had characteristics which indicated it to be a mixture of fatty acids of linseed oil and tung oil.

A similar condition was found in the insulation of some coils from oil-filled voltage regulators which failed in service. Again considerable discoloration of the cotton insulation by green copper soap was clearly visible and tests indicated high acidity and considerable copper content in all the insulation. A test specimen cut from the slot portion of one of the regulator coils was subjected to laboratory tests. The power factor of the insulation between adjacent conductors of adjoining layers was found to be 9.6 per cent, while the power factor of the insulation between adjacent conductors of the same layer was 59 per cent. The high power factor, low insulation resistance, and low dielectric strength of the insulation between adjacent conductors of the same layer are probably attributable to organic acids and resulting copper soaps.

The organic acids formed in the oil during its oxidation may be of various degrees of activity and are usually divided into the relatively strong acids soluble in water, and the weak acids insoluble in waters. Piper found that the so-called volatile acids, or those with low molecular weight have a marked effect on power factor of the oil and that the effect of any given amount of organic acids in the oil upon its electrical properties increases with decreasing molecular weight of the acid.[3] These acids are not only conducting but also corrosive in nature. While the action of organic acids is not so severe as that of mineral acids, the organic acids will react with and corrode the metals in contact with the oil and form metal soaps. As a rule, the more highly

[3] John D. Piper, N. A. Kerstein, and A. G. Heiger, "Oil-Impregnated Paper, Sorbtion of Organic Acids and Its Relation to Power Factor," *Industrial and Engineering Chemistry*, Vol. 29, September, 1937.

refined oils oxidize and form acids more quickly than oils not so highly refined. The oxidation of an insulating oil and the formation of organic acids may be accelerated by certain components of the solid insulation, particularly by some of the varnishes used on the windings.

Deterioration of all the forms of solid insulation evidenced by brittleness and crumbling of the materials was found during our investigation in a considerable number of transformers. In some cases the cotton insulation, while still intact, had deteriorated to such extent that it fell off the conductors when touched. The deterioration of the solid insulation appears to be the result of either oxidation or acid hydrolyzation or both. Preponderance of evidence, however, points to acid hydrolyzation. It is well known that cellulose absorbs and tenaciously holds acids which can only be removed by long contact with repeated changes of water.

Causes of Oil Deterioration:

Hundreds of thousands of tests have been made all over the country on all types of new and used oils. The voluminous data obtained have been carefully analyzed, and some of the summaries published. Available test data and other information indicate that the degradation of the electrical characteristics of an insulating oil in service is entirely due to the presence of the chemical oxidation products in the oil. The effects of this contamination are cumulative but not permanent. Removal of the contaminating oxidation products restores to the oil its original electrical properties.

Of the oxidation products, water, sludge, acids, and metal soaps appear to be the worst oil contaminants and perhaps also the most dangerous. Although only a small quantity of water may be dissolved in the oil, much of it may be present in suspension or in the form of an emulsion. While the water in solution increases the conductivity and power factor of the oil, it does not greatly affect its dielectric strength. It is the water in suspension even in such minute quantities as a few parts per million that has a very pronounced effect on the dielectric strength of the oil. The presence of water in a transformer also accelerates the formation of sludge and has other harmful effects on the transformer. Sludge thickens the oil, retards and sometimes even stops the circulation of the oil, decreases heat conduction and heat dissipation, and may cause overheating and subsequent failure of the transformer. Although sludge itself, when dry, has a relatively high dielectric strength, it absorbs moisture very readily and in the presence of moisture becomes a distinct insulation hazard. The organic acids are perhaps the worst contaminants of an insulating oil. Being highly conducting they increase the conductivity and power factor of the oil and decrease its dielectric strength.

Although the organic acids are weaker than mineral acids, they will, nevertheless, corrode the metals in contact with the oil, form metal soaps, and attack and gradually deteriorate the cellulose insulation of the transformer.

It appears to be general practice to consider the acids as just one of the oxidation products and to be concerned with the effects that the acids have upon the electrical characteristics of the oil without paying much or any attention to the deteriorating effect the acids have on the solid insulation of the transformer. Yet it is well known that the cellulose insulation used in transformers is not acidproof nor even acid resistant and that its useful life may be considerably shortened by the organic acids formed in the transformer oil. During our transformer inspections we have found that a large number of transformer failures were caused by a short circuit between adjacent turns of the winding. That is the place where only a cellulose type insulation is involved and where the concentration of the organic acids and the resultant formation of the metal soaps would be the greatest. Metal soaps being highly conducting and usually soluble in the oil increase its conductivity and lower its dielectric strength. Since their greatest concentration appears in the cotton insulation of the conductors, their presence is always potentially dangerous. The causes of contamination affecting the electrical properties of an insulating oil are, of course, so many and various that no attempt can be made to describe them all here. Balsbaugh[4] found that fundamentally it may be said that whatever increases the ionic content of the oil also changes its electrical characteristics.

Determination of Condition and Serviceability of the Oil:

Unfortunately we have no unit of deterioration and cannot express it as a definite numerical quantity. Deterioration of an oil is, therefore, not directly measurable, and the condition of an oil can at best be indicated only indirectly by measuring some of its physical, chemical, and electrical properties. This is done with the basic assumption that there is a definite relation between the measurable properties of the oil and its deterioration, although such a relation has not been definitely established as yet. But even if the chemical and electrical properties of an oil were a direct measure of its deterioration they still would not provide a complete solution to the problem of determining the serviceability of a used oil, because there is no known measure or relation which would reliably indicate how closely a certain degree of deterioration, whether chemical or electrical, approaches the end of serviceability of the oil. To be still serviceable, a used insulating oil must satisfy three main requirements: (1) it must still be a satisfactory dielectric, (2) it must still be a good cooling medium, and (3) it must not have any harmful effects on the solid insulating materials and metals of the transformer.

It is readily apparent that no single test now in general use, whether chemical or electrical, can give a satisfactory indication of all the oil properties involved in satisfying these requirements.

Since further serviceability of a used oil depends in the first place upon the combined effect all the contaminants present in the oil have upon its electrical characteristics, a real determination of serviceability of a used insulating oil should therefore be based on reliable information

[4] J. C. Balsbaugh and J. L. Oncley, "A Critical Study of Some Tests Used in the Investigation of Insulating Oil Deterioration," U.C.R. Committee Report on Insulating Oils and Cable Saturants. 1938.

about these effects and not simply on the knowledge of the amount of any or all of the contaminating oxidation products present in the oil or upon any one of its chemical or electrical characteristics.

It is well known that the changes taking place in the individual characteristics of insulating oils due to oxidation in service, resulting from exposure to air, are not uniform and that from case to case they may appear in unpredictable ratios. Clark found that the changes depend on the type of oil, on the nature and degree of refining, as well as on the conditions of oxidation.[2]

The conditions of oil oxidation vary from transformer to transformer and consequently no rigid generalizations can be made. In two transformers of the same make, size, and age, with the same oil subjected to the same service conditions, the rate of formation, the kind, and amount of oxidation products present in the oil do not have to be the same. There appears to be no definite ratio at which the various oxidation products are formed in the oil during its oxidation. Two oils having the same power factor may contain different amounts of sludge. Two oils having the same amount of sludge may vary in their acidities. An oil with a high acidity may have a low sludge content and one with a low acidity may have a high sludge content. It was found that in some cases the organic acids are used up in forming metal soaps as fast as they appear in the oil. That means that an oil with a low neutralization number may have a higher saponification number than one with a considerably higher neutralization number. The effect various combinations of the oxidation products present in the oil have on its electrical properties is by no means correspondingly uniform. Furthermore, some contaminants are known to have a pronounced effect only on one of the electrical properties of the oil and to produce only a negligible change in the others. Some have an effect on the electrical properties only if accompanied by another; for example, sludge and moisture.

None of the tests now in general use embraces the whole picture and, therefore, none alone can furnish the desired information. Any one of them has to be supplemented by other tests. But even if a series of the generally accepted tests is made on a used oil it may or may not show the true condition of the oil and, therefore, may or may not furnish the information necessary for a correct decision upon its serviceability. Since we are not certain in this respect, and since no definite relations between the oxidation products and their effect upon the electrical properties have been established, we cannot as yet satisfactorily express serviceability of a used oil as a function of its deterioration as reflected by the results of these tests. By this we do not mean to imply that these tests have no value or to minimize their importance. On the contrary, they are the only source of very important and useful information in studying the nature and causes of insulating oil deterioration. They will show the magnitude and rate of change in some of the oil characteristics as they are caused by service conditions or by controlled laboratory oxidations and will detect contamination or deterioration of the oil even in their early stages, and may be used as a production control of product quality and uniformity in the oil refineries. If used regularly they do help to reduce the number of transformer failures in service. Their chief significance, however, lies in that they provide about the only warning signals of approaching danger.

Although the results of these tests offer no positive indication that the oil is in good or bad condition, they do provide a definite clue as to the nature and degree of contamination and permit certain conclusions to be drawn about the condition of the oil. While it is true that all this is no more than a probability, it is equally true that this probability checks surprisingly well with the findings and experience obtained in field service. By means of laboratory tests on comparatively small samples we can quickly find what takes place in service over a period of years.

Of the many tests used in laboratory investigations, only a few fall within what we call routine practices. Although opinions, based on experience, about the merits and demerits of the individual tests vary considerably from laboratory to laboratory, there is no doubt that each of these tests is significant within its own scope. In practice it has been found that some of the electrical tests are more sensitive than others in detecting the presence of the contaminating oxidation products in the oil and in detecting its deterioration. Dielectric strength, power factor and d-c. resistivity have become very popular. They have been used for years and found to be the most practical for routine testing of insulating oils and their results serve as a very useful guide in the maintenance of transformers.

Interpretation of Test Data:

Unfortunately the results of the tests now in general use on insulating oils do not indicate reliably and conclusively when the oil ceases to fulfill its functions and when it should be discarded. This has to be decided by the maintenance engineer. Since there is no link connecting the causes and the effects, he must evaluate the data of the various tests on the basis of their relative importance from the standpoint of routine maintenance. He has to interpret the data using his judgment based on experience, make a diagnosis of the condition of the oil as reflected by the test results and decide whether the used oil is to be retained or discarded. To him this is not only a difficult but also a very annoying problem.

While the scientists and researchers are fundamentally concerned with the causes, the maintenance engineer is interested mostly in the effects these causes will ultimately have upon the electrical properties of the oil and upon the solid insulation of the transformer. He is principally interested in the value and rate of decrease of dielectric strength of the oil and in the increase of risk in operating a transformer with the used oil. From his point of view, there is only one purpose for making any tests on the oil, to get a quick, reliable, and convincing indication whether a certain oil is still serviceable. He knows that the service life of the oil has been shortened and he wants to know how much. For this reason alone, he submits a sample of the oil

for laboratory tests. He has a specific problem and from these tests he expects to get a definite but simple answer to his problem. He has a used oil and wants to be told whether it is safe to operate a transformer with this oil. Instead of being told, he first has to interpret some test data, then answer his own question, and finally make his own decision about the serviceability of oil. It seems to be clear that from the test results we are not able as yet to determine satisfactorily the condition of the oil and predict its behavior or service life. Thus, these tests, no matter how carefully made, cannot serve their purpose as far as the maintenance engineer is concerned, and the meaning of the test data will always be somewhat questionable until the test results can be reliably and consistently interpreted. If judgment based on experience is the deciding factor in the interpretation of the test data, the question immediately arises—how accurate and reliable is the decision itself?

Need for Limits:

Because of the present-day difficulties and uncertainties in interpreting the data, there is an urgent need among the maintenance engineers of the power companies for some definite standard method of interpretation and evaluation of the test data. The lack of such method has already led some maintenance engineers to place little reliance in the laboratory tests on oils. In fact there are some maintenance engineers who claim to be able to diagnose the condition of a used oil with equal reliability by just a visual examination and by smelling the oil.

Since we cannot always reliably and consistently interpret the test results in terms of condition or serviceability of the oil, then we should do the next best thing. If it is the effect of the oxidation products present which renders an oil unsatisfactory for further service, then it should be possible to set some limits for the allowable amount of these oxidation products in the oil and for the maximum allowable effect they may have on some of the measurable electrical properties of the oil which, when reached, would cause the maintenance engineer to discard the oil. Recognizing the difficulties and importance of the problem, some of the power companies have already set some arbitrary limits for at least some of the more important properties the of oil. Although these limits are not uniform and vary from company to company, it indicates that such limits can be established. Properly chosen and used limits would go far to remove the present difficulties and uncertainties connected with the interpretation of the test results and would greatly increase the usefulness of the tests. The establishing of such limits based on data obtained from actual service will be a big undertaking which should be carried out by no lesser authority than a national society.

The purpose of this paper has been to show that there is an urgent need not only for standard test methods but also for the interpretation of the test results, and to urge that the matter of first consideration be the establishing of limiting values for the maximum allowable amounts of the oxidation products in the oil and the maximum effect they will be allowed to have on some of the measurable electrical properties of the oil as a criterion of its serviceability.

DISCUSSION

Mr. E. M. Kipp.[1]—At the Symposium[2] in October, 1946 it was indicated that the analysis of many transformers in the field in which interfacial values and power factor values were taken showed that the power factors did not correlate with sludge in the transformers nearly as well as did the interfacial tension values.

I should like to ask Mr. Pohnan whether or not he feels, in view of the foregoing, that the interfacial tension values, let us say, would be a better single guide than a power factor on the oil itself.

Mr. F. J. Pohnan (*author*).—As I have emphasized at the beginning it is not my intention to advocate the preference for any one of the tests now in general use on insulating oils, nor to discuss their merits or demerits. All we are trying to do is to arouse the interest of a national body like the A.S.T.M. or the American Institute of Electrical Engineers for the establishing of standard limits for the tests now in use on insulating oils, including the interfacial tension test, which could be used as a conclusive indication whether a used oil is still serviceable.

Mr. Kipp.—I must apologize to the speaker. I do not think I phrased my question properly. All I was after was your personal opinion as to the value of the power factor test as a measure of oil quality in a transformer. What is your own private opinion?

Mr. Pohnan.—In my paper I have stated that none of the tests now in general use on insulating oils, alone, furnishes sufficient information for a real diagnosis of the condition of a used oil and that any one of them must, therefore, be supplemented by some other tests. We have been using power factor tests in connection with d-c. resistivity tests, so far with very good results. We have found that with any fundamental change in the oil the d-c. resistivity changes faster than power factor for new oils and slightly deteriorated oils, at about the same rate as power factor for medium oils and much slower than power factor for badly deteriorated oils. That means that the d-c. resistivity is more sensitive than power factor to detect any changes in good oils and that power factor is of greater value in an investigation of bad oils. After seeing some of the interfacial tension curves, I feel that the d-c. resistivity of an oil, from the beginning of its oxidation up to the point of sludge formation, changes just as fast, if not faster, than the interfacial tension.

Mr. J. C. Balsbaugh.[3]—Meas-

[1] Chief, Lubricants Div., Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa.

[2] Published in ASTM Bulletin, No. 146, May, 1947, pp. 90–100.

[3] Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

urements of the power factor of an insulating oil over a wide range of frequency indicates that practically all of the observed loss of power factor is due to the ionic conduction. The power factor of an oil is the ratio of the ionic component of current to the capacitance component of the current. Since the ionic component is independent of frequency and the capacitance component is directly proportional to frequency, power factor times frequency will be approximately a constant. Thus, the power factor of an oil at a frequency of 1 kilocycle per second will be approximately 0.06 of its value at a frequency of 60 cycles per second.

Most mineral oils contain a very small percentage of certain nonhydrocarbon components. These components are probably polar to some extent. Accordingly, in certain frequency and temperature ranges, the power factor due to ionic conduction is practically negligible and the power factor of the oil is due principally to these nonhydrocarbon components. It is believed that work of this type might be of importance in studying the action of these nonhydrocarbon components. It is known that certain additives in relatively small amounts can materially affect the performance of an insulating oil. However, these additives or nonhydrocarbon components do not contribute significantly to the 60-cycle power factor of usual test conditions.

[4] Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

MR. WILLIAM G. HORSCH[4].—There is one point—a minor one—which I should like to ask Mr. Pohnan. He mentioned at least one instance in which he found carbon in the aged oil. Was this important in quantity and appreciably significant, and how does he account for it?

MR. POHNAN.—An appreciable amount of carbon was found in the oil of only one transformer and we did not consider it a serious problem. In some of the other transformers, with a moderate amount of carbon in the oil, it was found that the black varnished tape was partially carbonized, apparently from overheating of the winding, and that the carbon found in the oil was probably due to this source.

Refresher on Statistical Analysis Applied to Two A.S.T.M. Oil Dielectric Strength Test Procedures[1]

By E. W. Greenfield[2]

GATHERING OF DATA

ACCUMULATION of facts from observation or experiment is, in the case of the physical sciences at least, generally represented as a group or a series of groups of numerical data. Depending upon the system of observation employed or conditions of experiment, the data obtained may be used:

(*a*) To determine the dependence of two or more variables,

(*b*) To interpret and ascertain the causes of observed phenomena,

(*c*) To determine the characteristic behavior of materials, and

(*d*) To determine the statistical distribution of the quality characteristics of a material or degree of precision afforded by a given test.

A given set of data may be used for any of the purposes outlined above but more often is used for all of the purposes. In general, the degree of control exercised over any set of observations must be increased as the number of purposes for which the data will be used is increased. By "controlled conditions" is meant the concept of *homogeneous* data representing results obtained by measurements made under essentially the same conditions on the same types of materials produced under the same essential conditions.

PRESENTATION OF DATA

The more data accumulated under controlled conditions, the more perfect are the reasoned results therefrom. However, the gathering of a great mass of data presents two major difficulties:

(*a*) The task of analysis and interpretation of the large range of values associated with the mass of data becomes more involved, and

(*b*) The expense in money and time naturally increases.

To obtain the high degree of accuracy inherent in large data masses yet minimizing the disadvantages of involved analysis and excessive testing, it is necessary and desirable to apply simple statistical theory. This has been recognized in all branches of science and many able mathematicians have contributed a large share of their life's work perfecting the theory and extending the usefulness of statistical treatment.

The A.S.T.M. Manual on Presentation of Data:

No organization has more fully recognized the value of statistical analysis than the A.S.T.M. To place the handling and analysis of data on a more efficient and scientific basis, the Society undertook, in 1933, the publication of its "Manual on Presentation of Data." This little book, prepared by an able committee, has been reprinted four times since 1933 and its original scope extended by the addition of two supplements.[3]

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] This is the fourth paper in the first series of the Symposium on Insulating Oil sponsored by Subcommittee IV on Liquid Insulation of Committee D-9 on Electrical Insulating Materials and held in Atlantic City, N. J., October 16, 1946. The other three, with discussion, appeared in ASTM BULLETIN, No. 146, May, 1947, p. 90.

[2] Engineer-in-Charge, Electrical Laboratory, Anaconda Wire and Cable Co., Hastings-on-Hudson, N. Y.

[3] "A.S.T.M. Manual on Presentation of Data Including Supplements A and B and Tables of Squares and Square Roots," Sponsored by Committee E-1 on Methods of Testing, Am. Soc. Testing Mats. (Issued as separate publication.) Acknowledgment is herewith made for text material and curves reproduced from the Manual.

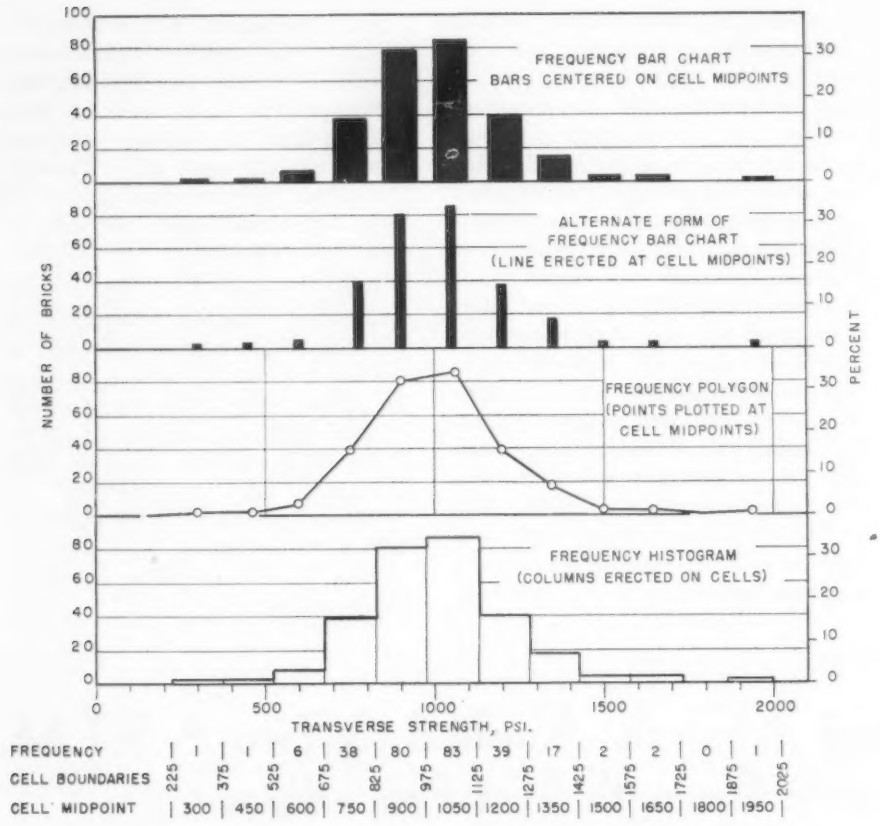

FREQUENCY BAR CHART
BARS CENTERED ON CELL MIDPOINTS
ALTERNATE FORM OF
FREQUENCY BAR CHART
(LINE ERECTED AT CELL MIDPOINTS)
FREQUENCY POLYGON
(POINTS PLOTTED AT
CELL MIDPOINTS)
FREQUENCY HISTOGRAM
(COLUMNS ERECTED ON CELLS)
NUMBER OF BRICKS
PERCENT
TRANSVERSE STRENGTH, PSI.
FREQUENCY | 1 | 1 | 6 | 38 | 80 | 83 | 39 | 17 | 2 | 2 | 0 | 1 |
CELL BOUNDARIES 225 375 525 675 825 975 1125 1275 1425 1575 1725 1875 2025
CELL MIDPOINT | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 | 1650 | 1800 | 1950 |

Fig. 1.—Graphical Presentations of a Frequency Distribution.

The Manual does not pretend to be a text or even a monograph on statistical theory. It merely presents those facts and statistical procedures which in the opinion of the Manual committee were deemed to be of material value for the purposes of A.S.T.M. Without further recourse to the literature, it is possible to apply effectively the information contained in the Manual to almost any type of A.S.T.M. problem. The author is of the opinion that a copy of the Manual should be owned by every member of the Society, its contents understood, and its recommendations as to the handling of data followed.

For those who have not familiarized themselves with the A.S.T.M. Manual on Presentation of Data, there are presented below a few of its highlights with particular application to a Dielectric Strength Test procedure problem on insulation oils. Keeping the scope of this paper well in mind, it will be necessary to restrict ourselves only to the portions of the Manual applicable to the problem at hand. One of the most valuable sections of the Manual therefore, is on "control chart" methods of analysis and will unfortunately not be reached.

Summarization of Data

In the study of a single property of a material, for example transverse strength of brick, the results of a number of tests will always present a rather wide range of values. The over-all picture of the results can best be obtained by arranging the data in some form of frequency grouping such that the *range of spread*, the *maximum and minimum values*, the *average value* and the *number of tests* become readily apparent. By setting up so-called equal "cell" boundaries and classifying each numerical value with the appropriate cell, a grouped frequency representation is obtained which not only condenses the data to pictorial form but permits ready evaluation of the factors mentioned above. The "frequency" for any cell is the number of observations in that cell and the relative frequency is the frequency for that cell divided by the total number of observations. With regard to choice of cell boundaries and number, these are dictated somewhat by the precision of the measurement and the number of measurements. Generally, cell boundaries should have numerical limits equal to twice the precision of test. For example, if dielectric breakdown is read to the nearest 50 v., the cell boundaries should be chosen to the nearest 25 v. The number of cells is preferably between thirteen and twenty, but if the number of observations is less than ten, a frequency distribution of the data will be of small value.

Figure 1 shows four possible types of frequency distributions for a given set of data. It is seen that whereas the total information contained in the original data is largely retained in the frequency distribution representation, the latter permits an immediate appraisal of the result not possible from the unorganized data. When the data are taken under controlled conditions, the form of the frequency distribution will be according to the so-called Normal Law equation or the Second Approximation equation (not shown by Fig. 1).

Whereas presentation in the form of a frequency distribution effects considerable condensation of the data, there are valuable advantages in further condensation to a few simple functions which numerically describe the form of the data distribution. These functions derive from the Normal Law equation and are thus applicable to data taken under controlled conditions. Three factors are found to be of most use in evaluating the data. They describe:

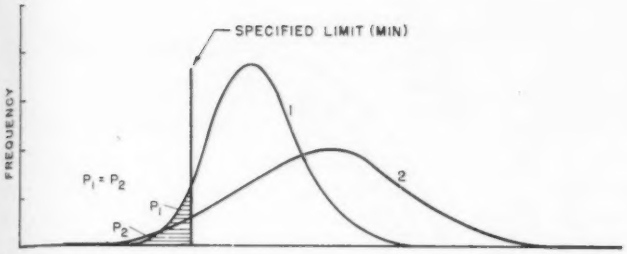
1. A measure of central tendency.
2. The spread or dispersion of values about the central value.
3. The way the observations group themselves with regards to symmetry about the central value.

Of the many functions which might be used to describe the above three factors, we find the following of greatest use:

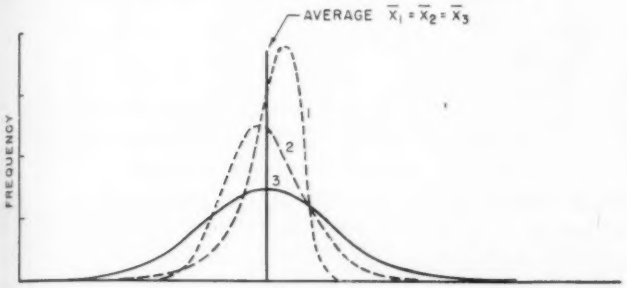
1. Arithmetical Mean, $\bar{x}$ (Average):

$$\bar{x} = \frac{\sum_{x_1}^{x_n} x}{n}$$

where $x_1, x_2 \ldots . x_n$ are individual

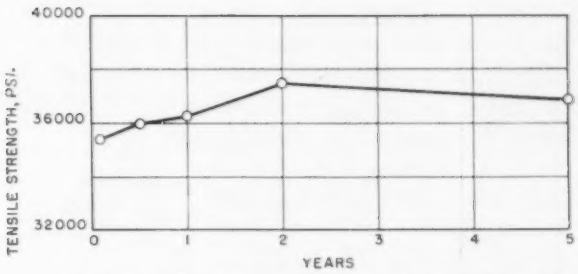


(a) TOTALLY DIFFERENT DISTRIBUTIONS MAY HAVE THE SAME VALUE OF P
FRACTION OF TOTAL OBSERVATIONS BELOW SPECIFIED LIMIT

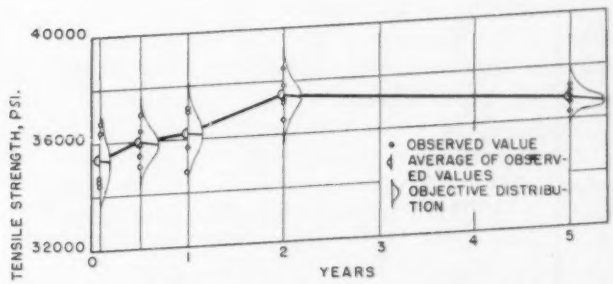


(b) TOTALLY DIFFERENT DISTRIBUTIONS MAY HAVE THE SAME AVERAGE

Fig. 2.—The Inadequacy of Single Functions to Describe a Frequency Distribution.



(a) AN EXAMPLE OF A GRAPH SHOWING AN OBSERVED RELATIONSHIP



(b) SHOWING WHAT LIES BACK OF THE PLOTTED POINTS IN GRAPH (a)
EACH PLOTTED POINT IN GRAPH (a) IS THE OBSERVED AVERAGE OF
A SAMPLE FROM AN OBJECTIVE FREQUENCY DISTRIBUTION

Fig. 4.—Dependent Variables, One Being Controlled.

values and n is the total number of values.

2. Standard Deviation, σ:

$$\sigma = \sqrt{\frac{\sum_{x_1}^{x_n} (x - \bar{x})^2}{n}}$$

3. Skewness, k: This is a measure of the "lopsidedness" of a frequency distribution. It is a pure number and may be negative or positive from zero depending on the direction of displacement from normal.

$$k = \frac{\sum_{x_1}^{x_n} (x - \bar{x})^3}{n\sigma^3}$$

In addition to the derived functions: average, standard deviation, and skewness, two other factors are of value. Range R is the difference between the maximum and the minimum value; relative frequency P is the fraction of the total number of observations lying within stated limits on the scale of measurement. Figure 2 indicates how relative frequency P, and arithmetic mean $\bar{x}$, when used alone can be misleading.

With the help of only two functions, average and standard deviation, it will generally be possible to estimate the percentage of the total number, n of a group of values, which lie between any stated interval $x = a$ and $x = b$, so long as a and b are symmetric about the average value. When the selected limits are not symmetric about the mean, use of the skewness factor k will provide a more accurate estimate. Figure 3 is a nomographic chart based on the Normal Law integral. By means of this chart, it is possible to approximate the percentage of total observations lying within any given symmetric range: $\bar{x} \pm t\sigma$. The larger the number of observations the better the approximation.

As an example, consider a group of homogeneous data yielding a value of standard deviation, σ; it is required to estimate what percentage of the total number of observations will fall within plus or minus twice from the mean. In Fig. 3, opposite 2 on the t scale, find 95.45 on the percentage scale; this is the result sought. Obviously, the greater the standard deviation the less efficient the data from a statistic viewpoint, thus connoting more variability of material, test methods, or both.

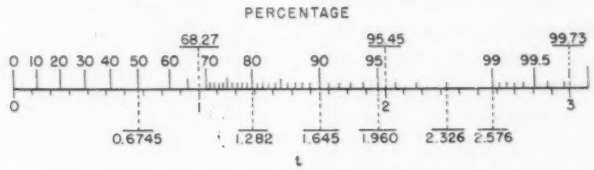


Fig. 3.—Normal Law Integral Diagram Giving Percentage of Total Area Under Normal Law Curve Falling Within the Range $\bar{x} \pm t$.

Figure 4 (*a*) shows an observed relationship between tensile strength and aging time. Figure 4 (*b*) shows the frequency distribution of each measured point and this provides some idea of the reliability of each averaged value. On the whole, it would appear that as the test proceeded the reliability of each determined average point improved. This could be expressed numerically by setting down the standard deviation along with each plotted point.

Limits of Uncertainty of an Observed Average

Next to efficient summarization of a set of data, we should like to be able to assign to a given average, computed from a relatively small number of observations, a definite plus-minus range within which the true average may be expected to lie. By true average is meant the statistical average obtained as the number of observations are increased to include every possible sample of the universe of samples.

When the data are homogeneous

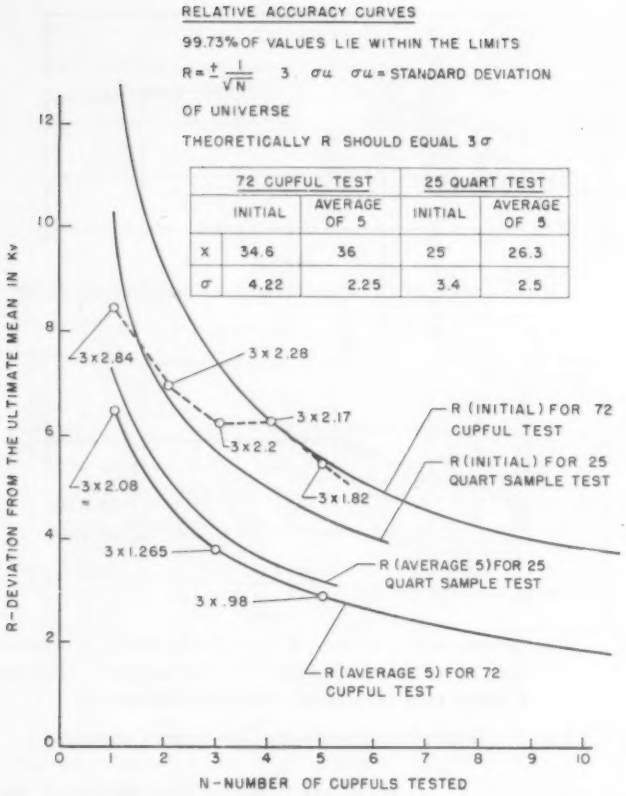

RELATIVE ACCURACY CURVES
99.73% OF VALUES LIE WITHIN THE LIMITS
$R = \pm \frac{1}{\sqrt{N}} \quad 3 \quad \sigma u \quad \sigma u$ = STANDARD DEVIATION OF UNIVERSE
THEORETICALLY R SHOULD EQUAL 3σ
72 CUPFUL TEST
25 QUART TEST
INITIAL
AVERAGE OF 5
INITIAL
AVERAGE OF 5
x 34.6 36 25 26.3
σ 4.22 2.25 3.4 2.5
3x2.84
3x2.28
3x2.17
3x2.2
3x2.08
3x1.82
3x1.265
3x.98
R (INITIAL) FOR 72 CUPFUL TEST
R (INITIAL) FOR 25 QUART SAMPLE TEST
R (AVERAGE 5) FOR 25 QUART SAMPLE TEST
R (AVERAGE 5) FOR 72 CUPFUL TEST
R-DEVIATION FROM THE ULTIMATE MEAN IN Kv
N-NUMBER OF CUPFULS TESTED

Fig. 5.—Correspondence Between Various Tests and Theoretical Prediction of Accuracy.

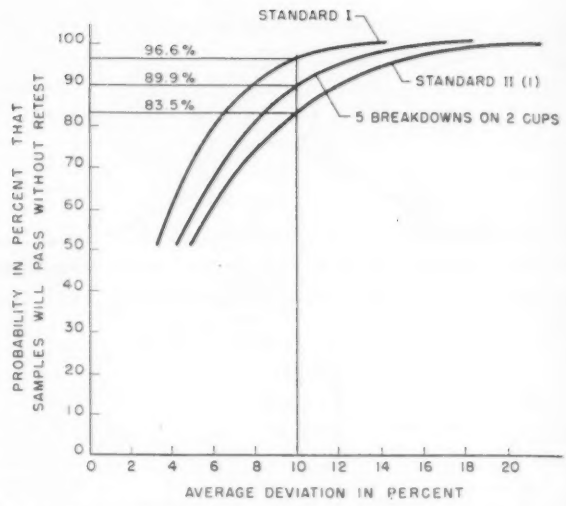


Fig. 6.—These Curves Show the Amount of Retesting Required Using Various Test Procedures.

Standard I. *Present A.S.T.M. Standard:* Five breakdowns on each of three cups. Average breakdowns on each cup to be within 10 per cent of mean of three cups.

Standard II. *Tentative A.S.T.M. Standards:*

(1) One breakdown on each of five cups. Average deviation to be within 10 per cent of average. Also, individual deviations to be within 25 per cent of average.

(2) One breakdown on each of two cups: (*a*) If neither breakdown below specified limit, no further tests required. (*b*) If either below specified limit, three additional tests required.

or controlled, the frequency distribution follows the Normal Law and the sample is a true random sample; it will in general be possible to write down an average plus or minus limiting deviation within which range the true average can be stated to be within a definite statistical probability.

For example, given a set of data taken on a limited number of samples which yields an average $\bar{x}$ and a standard deviation σ, the true average will then lie within the range

$$\bar{x} \pm a\sigma$$

in P_s per cent of instances. Here P_s simply expresses the probability of this being so, in per cent. For the number of observations, n, greater than 25

$$a = \frac{t}{\sqrt{n-3}}$$

where t may be picked off the nomogram in Fig. 3 for any desired per cent probability.

For smaller values of n, a for any decimal probability can be found by means of the probability chart given in Fig. 7.

Consider a set of data obtained by making ten breaking strength determinations on a given sample of hard-drawn copper wire for which:

$$\bar{x} = 575.2 \text{ lb.}$$

$$\sigma = 8.26 \text{ lb.}$$

For a P of 90, a will be found equal to 0.611. Hence:

$$\bar{x} \pm a\sigma = 575.2 \pm 5.1$$

This means that the true average breakdown strength of the wire will lie between 570.1 and 580.3 in nine out of ten instances when the sample observations are limited to only ten in number. If we had desired a higher probability, say 99 in 100 instances, a must naturally be larger. It turns out actually to be 1.08 and

$$\bar{x} \pm a\sigma = 575 \pm 8.94 \text{ or } (566.1 \text{ to } 583.9)$$

If the true average and standard deviation of all possible samples (universe) are *known*, then a simpler statement for probable error can be set down, for example: where $\bar{x}'$ refers to the true average and σ' refers to the standard deviation of the true average,

$$\bar{x}' \pm 0.6745 \frac{\sigma'}{\sqrt{n}}$$

denotes that the error in the mean for any limited number of observations, n, will lie within the range $0.674(\sigma'/\sqrt{n})$ in 50 per cent of instances. To obtain a better probability, the value of t (in Fig 3). opposite the required per cent probability is used in place of 0.674. For example, if we require the limits such that the true average will lie within the range computed in 99

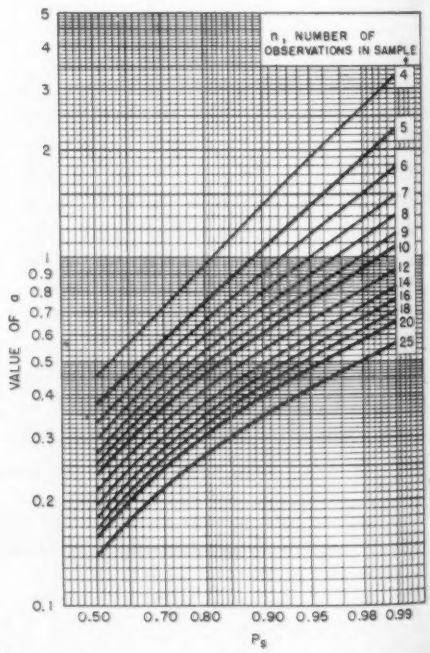


Fig. 7.—Curves Giving Values of a and P_s.

per cent of instances, we would find:

$$\bar{x}' = \frac{2.576\sigma'}{\sqrt{n}}$$

Use of the above simple equations for probable error are of value where it is desired to check the accuracy limitations of a small number of observations in a given set of a large number of samples.

Application to Oil Breakdown Strength Tests

The present Standard Methods of Testing Electrical Insulating Oils (D 117)[4] for insulating oils requires that five breakdowns be made on each cup filling. The test is then to be repeated with additional refills until the averaged value of each of at least three fillings does not differ from their mean by more than 10 per cent. The proposed modification for this test is as follows:

(*a*) One breakdown test shall be made on each of five fillings of the test cup. If the average deviation from the mean exceeds 10 per cent or if any individual test deviates more than 25 per cent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first five tests that conform to the allowable variations.

(*b*) For specification limit purposes only, one breakdown on each of two fillings may be made and providing each breakdown exceeds the requirement, the oil is deemed to be satisfactory. If not, the provisions of (*a*) above must be carried out and a breakdown value determined.

Report of Hydro-Electric Power Commission of Ontario

In a report dated February 28, 1946, Mr. Frank Noakes of the Hydro-Electric Power Commission of Ontario presented analyzed results of a large number of dielectric strength tests on new and used transformer oil. These tests may be grouped as follows:

1. 822 random samples from all sources. Five breakdowns on a single cup filling.
2. 100 cupsful on one sample of used oil. Five breakdowns on each of many cup fillings.
3. 72 cupsful each of a single sample of new and used oil.
4. 25-qt. samples of used oil, partly filtered, five breakdowns on each of many cup fillings.

Test groups 3 and 4 permitted statistical treatment to determine the relative desirability and usefulness of the present and proposed A.S.T.M. test methods. This follows since for a given large sample (universe), if a large amount of data under controlled conditions is taken so that the true average and its standard deviation become known, then a measure of the accuracy obtainable using a smaller number of tests may be determined from probability tables.

For the 72-cupful group and the 25-qt. sample, Noakes prepared averages and standard deviations for both the first and five breakdowns for one to five cup fillings. By plotting both the averages and the standard deviations against filling number or breakdown number, the systematic variations were readily visualized. For example, it was disclosed that no progressive increase (or decrease) in the mean of the average of five breakdowns per filling occurred when each cupful was considered separately and that this was substantially true for single breakdown fillings although the spread was larger. The effect of including more breakdowns in the averaging of initial breakdowns resulted in little change in the mean but steadily decreasing standard deviation.

Figure 5 is a reproduction of Fig. 6 in Noakes' report. Two sets of solid curves are shown for each of the 72-cupful and the 25-qt. groups corresponding to one breakdown per-cup-tests and five breakdown per-cup-test. In each case the true average and its standard deviation are known (results of all the tests made). Using a 99.73 per cent probability, the curves show how large the deviation from the true average will result by tests made on 1, 2, 3, 4, 5, etc., cupsful. Individually averaged tests on these numbers of cupsful should, for the same probability of 99.73 per cent, theoretically show a deviation from the true mean of 3σ. To test the statistical soundness of the data, the 3σ values were computed and are shown as experimental points in Fig. 5. It is seen that for the average of five breakdowns per cupful, the correlation is excellent and indicates good reproducibility. The correlation for the initial breakdown tests is not so good and this, of course, results from the larger variation in standard deviation.

Specifically comparing the A.S.T.M. proposals, the 25-qt. sample is analyzed further in Fig. 6. Here it is shown that the present A.S.T.M. standard will, in 96.6 per cent of the tests, pass oil with less than 10 per cent average deviation, whereas the proposed one-shot-per-cup-test will do so only in 83.5 per cent of instances. This curve is made up as follows: Considering the five-shot-per-cup-tests, an average of 26.84 kv. with a standard deviation of 1.265 is found. Hence, a 1σ deviation amounts to 4.72 per cent of the average and from Fig. 3 indicates a 68 per cent probability. A 10 per cent deviation would be given by $\pm 2.1\sigma$. Referring again to Fig. 3, opposite 2.1 is found 96.6 per cent which is the probability corresponding to the 10 per cent limiting deviation set up in the method. By taking other values corresponding to various percentage deviations, the rest of the curve may be set up.

The analysis, therefore, indicates that where there is a limited number of fillings, greater accuracy is obtainable by the five-breakdown-per-filling method. Based upon these observations, Noakes suggests the following method to be used for dielectric strength testing of oil:

(*a*) "Except as specified in Paragraph (*b*), 5 breakdowns shall be made on each of the 3 fillings of the test cup. If the average deviations from the mean exceeds 10 per cent or if any individual test deviates more than 25 per cent from the average, additional tests shall be made. The dielectric strength shall be determined by averaging the first three tests that conform to the permissible variations.

[4] 1946 Book of A.S.T.M. Standards, Part III-A, p. 214; Part III-B, p. 65. (For tentative revision, see Part III-A, p. 869; Part III-B, p. 600.)

(*b*) "When oil is tested in considerable quantity, so that the time required for testing in accordance with paragraph (*a*) is excessive, and when it is merely desired to determine whether the breakdown safely exceeds the limit specified, or in those cases where the amount of oil available for test may be very limited, 5 breakdowns shall be made on one filling of the test cup. The average of the 5 breakdowns shall be taken as the dielectric strength of the oil with no further tests required."

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Discussion of Paper on A Rapid Method for Accurate Yield Strength Determination Without Stress-Strain Curves[1]

MR. H. A. SENIOR[2]—The above paper and relevant discussion have been read with considerable interest by members of the Metallurgy Section, Aeronautical Inspection Department, Test House. I should like to offer some comments in the light of their extensive experience in the development of methods for testing of aircraft materials.

There is general agreement that the method described in the paper is fundamentally sound and of useful practical application. The desirability of avoiding the tedious work involved in plotting load-elongation or stress-strain curves has been fully appreciated during high-speed routine testing of aircraft materials, and particularly of high-strength light alloys. For this reason, for a number of years the Aeronautical Inspection Department has recommended the use of the "four-point" method which is not less accurate than the one described by Ebert. A pair of operators can achieve a speed of approximately one test in three minutes using the "Beaumont" proof stress indicator. Full details of the method and the indicator are given in the book by R. A. Beaumont.[3]

Mr. R. A. Beaumont of the College of Aeronautical Engineering, London, has developed a dial-type indicator method which appears to be capable of greater accuracy.[4] This method is based on a theory similar to that advanced by Ebert, but it is considered to have two advantages over Ebert's method in its practical application:

1. It gives an accurate proof stress value based on the actual elastic modulus of the particular specimen under test.

2. As the load-indicating pointer on the tensile machine is also used to show the theoretical extension, the number of points to be observed by the operator are reduced.

The term proof stress used above is used in this country and is defined as the stress which is just sufficient to produce a permanent elongation equal to a specified proportion of the original gage length.

The calculation involved in the method described in the paper requires a knowledge of the elastic modulus, and implies that this characteristic is constant for each material. With the majority of wrought aluminum alloys, however, experience has shown that the modu-

[1] L. J. Ebert, M. L. Fried, and A. R. Toole, "A Rapid Method for Accurate Yield Strength Determination Without Stress-Strain Curves," ASTM BULLETIN, No. 145, March, 1947, p. 50; discussion, No. 148, October, 1947, p. 94.

[2] Ministry of Supply, Aeronautical Inspection Dept., Test House, Harefield, Middlesex, England.

[3] R. A. Beaumont, "Mechanical Testing of Metallic Materials with Special Reference to Proof Stress," Sir Issac Pitman & Sons, Ltd., London, Second Edition (1944).

[4] *Aircraft Production*, Vol. VIII, No. 87, January, 1946.

lus varies between 10,000,000 and 11,000,000 psi.; for specimens of material with the maximum or minimum modulus value, the assumption of a figure of 10,400,000 psi. can introduce errors of up to 200 psi.

Under the paragraph headed "Operation of the Rapid Method," no provision is made to insure that any slight bends in the specimen are straightened by an initial tensioning stress. Test specimens from thin-gage light alloy sheets are particularly prone to this defect and determinations of proof stress made without preliminary straightening of slightly bent specimens have shown errors as great as 1100 psi. This difficulty can be alleviated by applying a small tensioning stress before setting the extensometer to zero at the beginning of the test and adjusting the load-elongation figures; at the Test House, test pieces for proof stress determination are normally given an initial tensioning stress of approximately 25 per cent of the specified minimum proof stress value.

In Mr. Howell's contribution to the discussion, mention is made of the use of the autographic extensometer. A Templin autographic extensometer has been in use at the A.I.D. Test House for several years and it has been found that more rapid and accurate proof stress determinations can be made by the use of a two-pencil device in lieu of the construction of offset lines after the charts have been removed from the recorder. Details of this device, which was developed by W. Thompson of our Mechanical Test Laboratory, have been made known to the manufacturers of the extensometer. The second of the two pencils is set in such a position that it draws the offset parallel line while the diagram is being produced. At the finish of the test a flexible rule is used to extend the straight portion of the offset line until it intersects the load-extension diagram. When the pencil is returned to the point of intersection the dial indicator needle of an Amsler type tension testing machine will register the proof load.

A further suggested improvement to the "Templin" recorder put forward by Miss V. Boxshall also of our Mechanical Test Laboratory, utilizes the fact that with a magnification of 500 to 1, the speed of rotation of the extensometer torque tube is such that one revolution indicates a gage length extension of 0.005 in. Thus, with a calibrated dial and needle pointer fitted, extensions within the elastic range can be checked against loads as the test proceeds, giving the operator a useful visual verification that the test is being carried out under controlled conditions.

MESSRS. L. J. EBERT, M. L. FRIED, AND A. R. TOOLE (*author's closure by letter*).—The authors appreciate the interest shown by Mr. Senior and are grateful for his comments.

Mr. Senior's objection to the use of an average value (10,300,000 psi.) for the modulus of elasticity of aluminum has been noted. Attention is called to Table I in the paper, which compares results obtained using the Rapid Method with results obtained by use of highly accurate equipment on a high-strength aluminum alloy. The maximum difference was ±200 psi. and over 50 per cent of the values agreed well. This alloy was tested in strip form and no tensioning stress was applied before testing. The Rapid Method is at least as accurate for the lower strength aluminum alloys.

Inconsistencies such as bent or badly aligned specimens are immediately apparent. It is necessary merely to compare the gage reading at any load to previously calculated values or to the total strain value given on the chart minus 0.0040 in.

Only one load need be recorded to determine the yield strength when the Rapid Method is used. Since no tensioning stress is applied and since no attempts are made to correct for slight variations in the modulus, the Rapid Method is actually faster and easier to use than the methods referred to by Mr. Senior. It is true that an error of ±200 psi. is possible when the Rapid Method is used, but the authors feel that errors in measurement, dial reading, and equipment could easily result in individual or cumulative errors of the same order.

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